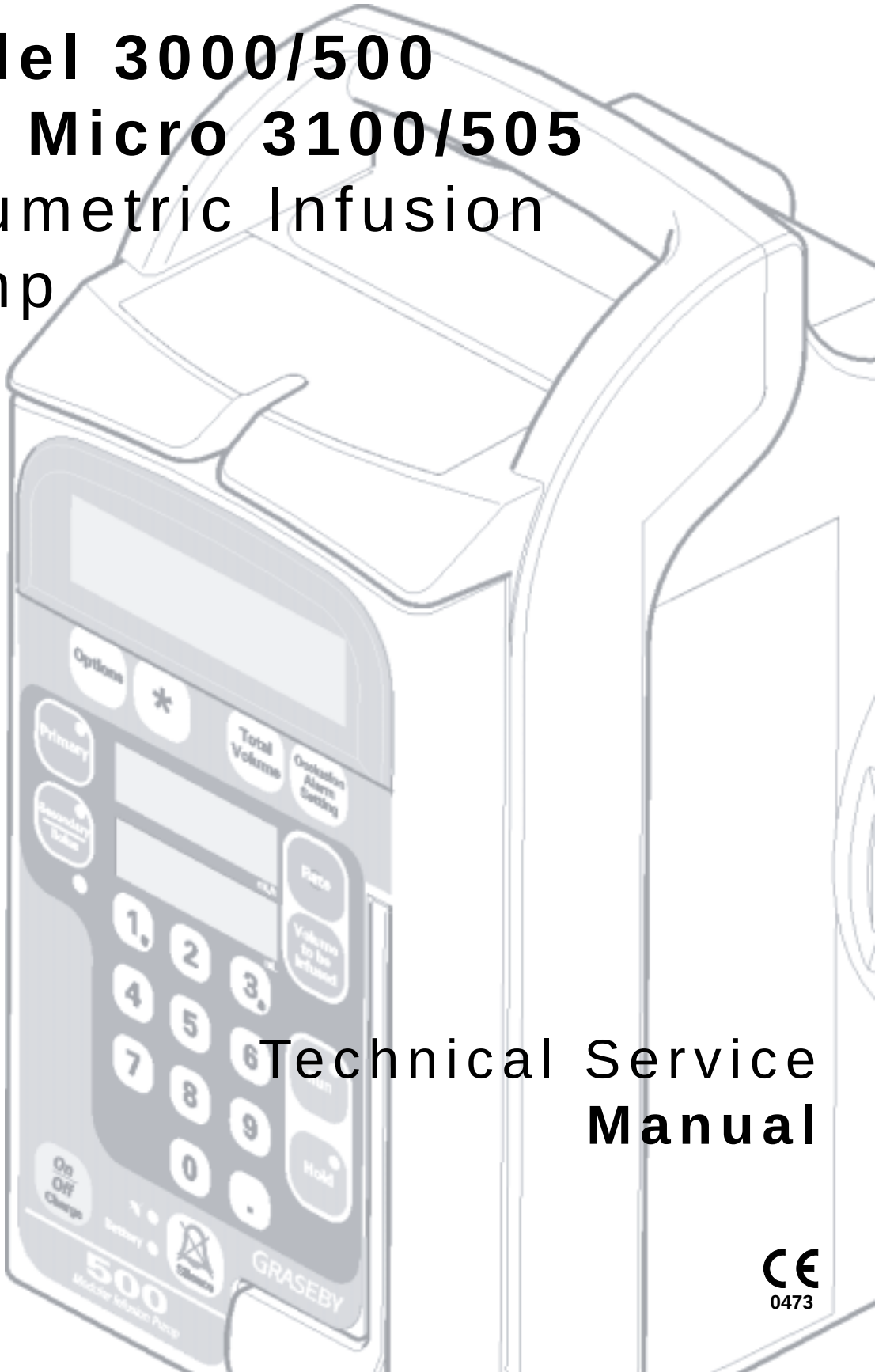
GRASEBY

Model 3000/500 and Micro 3100/505 Volumetric Infusion Pump



Technical Service **Manual**

CE 0473

Warnings

Warnings tell you about dangerous conditions, that could lead to death or serious injury to the user or patient, that can occur if you do not obey all of the instructions in this manual.

1. **WARNING: You should ensure that the performance offered by the pump is fit for the intended purpose. Failure to do so may result in compromised function of the product, patient injury or user injury.**
2. **WARNING: Do not use a faulty pump. If the pump detects a fault when it is first turned on, or if it develops a fault during operation then a continuous system alarm sounds. The pump must be referred to a suitably qualified technician or returned to Graseby Medical in order to have the fault rectified.**
3. **WARNING: Before using the pump, it should be inspected for physical damage. The pump should not be used if damage is evident, and should be returned to service personnel for repair before being returned to use. Failure to do so may result in compromised function of the product, patient injury or user injury.**
4. **WARNING: Do not use the pump if you detect any cracks, chips and loose or bent parts, or if the buttons do not move in and out freely when they are pressed. Failure to do so could cause inadvertent disconnection of the pumps.**
5. **WARNING: Do not push or pull on the pumps, or the IV pole may tip over or the pumps fall to the floor. Do not try to remove modular connected pumps from the IV pole whilst they are joined together. Either of these could cause the administration set to separate from the fluid container thus spilling the medication, or the pumps themselves could be damaged.**
6. **WARNING: Correct entry of data is essential in order to ensure that the intended infusion is performed. Before confirming any displayed data when setting up an infusion, you should ensure that it is correct. Failure to do so may result in compromised function of the product, patient injury or user injury.**
7. **WARNING: Dose-rate calculation requires care in entering data. Refer to specific product drug labelling for information on appropriate administration techniques and dosages. Entering incorrect data may result in patient injury or death.**
8. **WARNING: When delivering drugs in the epidural space, use only those medications specifically indicated for epidural use. Epidural administration of other drugs could result in serious patient injury or death.**
9. **WARNING: The use of administration sets incorporating injection sites could lead to an improper or inappropriate infusion resulting in serious patient injury or death.**
10. **WARNING: Failure to clearly identify the pump and administration sets could lead to an improper or inappropriate infusion resulting in serious patient injury or death.**
11. **WARNING: Remove any air to prevent air embolism. The presence of air within the infusion can result in complications resulting in patient injury or death.**
12. **WARNING: To avoid over infusion, do not prime the infusion line when the administration set is connected to the patient. Over infusion can result in patient injury or death.**
13. **WARNING: The Occlusion alarm level must be checked before starting an infusion to ensure that it is appropriate for the infusion. Failure to do so may result in an unacceptably slow time to Occlusion alarm, resulting in patient injury or death.**
14. **WARNING: Prior to starting an infusion, inspect the fluid path for kinks, a closed clamp or other obstructions. Failure to do so may result in the infusion not being delivered correctly, resulting in patient injury or death.**
15. **WARNING: If using a blood pressure cuff above the patient's venipuncture site take extra care in setting the Occlusion alarm pressures. Failure to do so may result in unnecessary Occlusion alarms, resulting in patient injury or death.**
16. **WARNING: The Occlusion detection system measures downline pressure in the administration set, but does not detect infiltration. In accordance with local protocol, you must periodically inspect the patient's infusion site for signs of infiltration. Failure to do so may result in an unacceptably slow time to Occlusion resulting in patient injury or death.**
17. **WARNING: If an Occlusion alarm occurs, immediately clamp the line to the patient. Then inspect the fluid pathway to determine what has caused the obstruction. An unintentional bolus of medication can result in patient injury or death.**
18. **WARNING: Do not run parallel infusion lines below the pump. Delivering a Secondary infusion means running a second line *above* the pump. Failure to do so may result in an inaccurate delivery of medication, resulting in patient injury or death.**
19. **WARNING: Check the Secondary set carefully, since an occlusion above the pump on the Secondary line could cause the Primary fluid to be delivered instead of the Secondary infusion. Administering the wrong medication may cause serious patient injury or death.**

20. **WARNING: The Secondary volume to be infused must match the amount of fluid in the secondary container. Primary flow resumes when the secondary container is empty. If the volumes do not correspond, the wrong infusion may be delivered which could cause serious patient injury or death.**
21. **WARNING: Correct management of battery charging, as described in this documentation is essential to ensure that the pump can operate on battery for the time specified. Failure to do so may result in compromised function of the product or patient injury.**
22. **WARNING: If a backup alarm sounds, the pump should be immediately removed from the patient and sent to be repaired by a Graseby Medical qualified technician. Failure to do so may cause patient injury or death.**
23. **WARNING: Failure to use the power cord retainer means that the pump may be accidentally or erroneously disconnected from the mains. Although there is a battery backup in case this happens, the battery may not be charged sufficiently. Consequently, there is a risk of the pump not functioning which could lead to patient injury or death.**
24. **WARNING: Do not open the pump housing. Refer all service faults only to qualified technical personnel. Opening the pump housing may cause electric shock leading to patient or user injury or death.**
25. **WARNING: When the pump is carrying out an infusion, to ensure that electrical safety is maintained, only items of equipment that conform to EN60950 are to be connected to the RS232 connector situated at the back of the pump, otherwise patient safety may be compromised.**
26. **WARNING: While Graseby Medical Limited have taken all reasonable steps to ensure that the pump operates correctly while under remote control, it is the responsibility of the person who designs and implements the controlling device to ensure that the resulting system (pump and controlling device) is fit for its intended purpose. Failure to do so may result in compromised function of the product, patient injury or user injury.**
27. **WARNING: Use only Graseby Medical administration sets with this product. Failure to do so may result in compromised system accuracy leading to complications resulting in patient injury or death.**
28. **WARNING: Do not perform these tests while the pump is in use on a patient, as this may cause patient injury or death.**
29. **WARNING: Unplug the AC power cord before opening the pump housing to avoid risk of electric shock, which could result in death or serious injury.**
30. **WARNING: Potentially dangerous voltages are exposed when the pump housing is open and the AC power cord is plugged in. These voltages are present in the transformer and AC fuse on the CPU/Power supply board and the RFI line filter where the power cord connects. To avoid electric shock with potential for severe injury or death, do not touch these areas when the power cord is plugged in.**

Cautions

Cautions tell you about dangerous conditions that can occur and cause damage to the pump if you do not obey all of the instructions in this manual.

1. **CAUTION: Refer all service, repair and calibrations only to qualified technical personnel. Unauthorised modifications to the pump must not be carried out.**
2. **CAUTION: Do not autoclave, steam sterilize, ETO sterilise or subject the pump to temperatures in excess of 45° C (113° F). Excessive temperatures may cause damage to the pump.**
3. **CAUTION: To prevent serious damage to the pump it must not be immersed in any liquids or exposed to strong organic solvents. Wipe off spills immediately. Do not allow fluid or residues to remain on the pump. Additionally, the pump is not designed to allow it to be sterilised. Failure to observe these cautions may cause internal damage to the pump.**
4. **CAUTION: Carry out periodic cleaning following the detailed instructions in this manual Do not use unapproved cleaning agents.**
5. **CAUTION: When turning the pump on, if screens similar to those illustrated are not displayed, do not use the pump, and send the pump to authorised service personnel.**
6. **CAUTION: Only carry the pump by the handle. Failure to do so may result in damage to the pump, or the pump may be dropped which could cause internal damage to the pump.**
7. **CAUTION: The backlight has a limited life and may, if used constantly, cause the light to dim. Eventually the message display may then need to be replaced. To preserve the life of the message display, you should only turn on the Message Display Light as described here if it is specifically required. Misuse of this feature could lead to both battery and LCD depletion.**
8. **CAUTION: The Functional and Accuracy Check should be performed following any significant disassembly or repair of the pumps.**
9. **CAUTION: The circuit boards consist primarily of surface mounted technology, component level repairs are not recommended.**
10. **CAUTION: Disconnect the battery connection P104 on I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the *On/Off* key twice to discharge the circuitry.**
11. **CAUTION: Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.**
12. **CAUTION: Do not use a screwdriver or other sharp instrument to separate the front and rear housing as this action could cause pump damage.**
13. **CAUTION: Do not damage or puncture the kapton tape. If the tape is damaged or punctured it could result in the pump not being ESD protected. Special care should be taken when placing the kapton tape and also when assembling the front and rear cases together as the front case lugs may puncture the tape.**
14. **CAUTION: Crossed wires must be shielded with suitable insulation as described. Failure to carry out the procedure as specified may result in permanent damage to the LCD.**

Published by Graseby Medical Limited.
All possible care has been taken in the preparation of this publication, but Graseby Medical Limited accepts no liability for any inaccuracies that may be found.

Graseby Medical reserves the right to make changes without notice both to this publication and to the product which it describes.

© **Graseby Medical Limited 2002**

No part of this publication may be reproduced, transmitted, transcribed, or stored in a retrieval system or translated into any human or computer language in any form by any means without the prior permission of Graseby Medical Limited.

GRASEBY MEDICAL LTD,
Colonial Way,
Watford,
Hertfordshire,
UK
WD24 4LG

TEL: (+44) (0)1923 246434
FAX: (+44) (0)1923 231595
WEB: www.graseby.co.uk

REGISTERED IN ENGLAND

COMPANY No. 995550

Trademarks and acknowledgements:
"Graseby"; and Smiths are all trademarks of the Smiths Group plc.

All other trademarks are acknowledged as the property of their respective owners.

ISSUE RECORD			
Issue No.	**Reason for change**	**Pages effected**	**Date**
A	Initial issue	All	April 2002

Contents

Chapter 1 - Introduction

Introduction

Scope of this manual ..... 1 - 1
Related manuals ..... 1 - 1
Graseby service contacts ..... 1 - 1

Product Overview ..... 1 - 2

System description ..... 1 - 2
Optional labels ..... 1 - 2
Software versions ..... 1 - 2

Chapter 2 - Specification

Specifications ..... 2 - 1

Standards ..... 2 - 8

Trumpet curves ..... 2 - 9

Chapter 3 - Overview of Pump Operation and Initial Checks

Overview of Pump Operation & Initial Checks ..... 3 - 1

Exterior of the 500/3000 pump - front ..... 3 - 2
Exterior of the pump - rear ..... 3 - 3
How the pump is powered ..... 3 - 4
How the pump works ..... 3 - 5
Power up tests and checks ..... 3 - 9
Powering down ..... 3 - 12
Power monitoring ..... 3 - 13
Alarms ..... 3 - 15

Chapter 4 - Volumetric Pumps Menus

Volumetric Pump Menus ..... 4 - 1

Which version of software is in the pump? ..... 4 - 1
Introduction to menus ..... 4 - 1
About the Technician menu ..... 4 - 2
Summary of Technician menu parameters ..... 4 - 3
Using Technician parameters ..... 4 - 4
About the Biomedical menu ..... 4 - 8
Summary of Biomedical menu parameters ..... 4 - 10

About Snapshot screens ..... 4 - 11
Decoding Snapshot screen-a ..... 4 - 12
Decoding Snapshot screen-b ..... 4 - 15
Using Biomedical Parameters ..... 4 - 22
Enabling special programming functions ..... 4 - 27
About the Service Functions menu ..... 4 - 29
Service Functions menu parameters ..... 4 - 30

Chapter 5 - Mechanical Systems

Mechanical Systems ..... 5 - 1
Linkage system ..... 5 - 1
Cassette housing and door ..... 5 - 2
Safety clip retention slot ..... 5 - 2
Cam housing switch and safety clip switch ..... 5 - 4
Cam housing ..... 5 - 4
Stepping motor ..... 5 - 4
Cams, pistons and valves of the pumping mechanism ..... 5 - 6
Encoder wheel and interrupter ..... 5 - 9
Empty bag contacts ..... 5 - 10
Sensors ..... 5 - 10
Pole clamp and IV pole ..... 5 - 12
Modular connection system ..... 5 - 12

Chapter 6 - Electronic Circuits

Electronic Circuits ..... 6 - 1
Definitions ..... 6 - 1
Functional block diagram ..... 6 - 1
System control ..... 6 - 2
Power ..... 6 - 2
Interconnection summary ..... 6 - 3
PCB design ..... 6 - 3
CPU/power supply board ..... 6 - 3
Power supply ..... 6 - 9
I/O board ..... 6 - 11
Display board ..... 6 - 14
RS232 interface ..... 6 - 17

Chapter 7 - Maintenance Procedures

Maintenance Procedures ..... 7 - 1
Introduction ..... 7 - 1
Recommended test equipment ..... 7 - 2
Recommended troubleshooting equipment ..... 7 - 2
Service tool kit ..... 7 - 3
Periodic cleaning ..... 7 - 4
Recommended yearly checks and tests ..... 7 - 6
Recommended Functional & Accuracy Tests: Checklist ..... 7 - 18
Troubleshooting ..... 7 - 19
Replacing the LCD ..... 7 - 23
Reinitialising the pump after replacing the NVRAM (IC18) ..... 7 - 25
Adjustment of the “Cassette Fitted” micro switch ..... 7 - 32

Chapter 8 - Disassembly and Reassembly Instructions

Disassembly and reassembly instructions ..... 8 - 1
Battery removal ..... 8 - 1
AC fuse removal ..... 8 - 1
Front housing removal ..... 8 - 2
Door assembly removal ..... 8 - 3
CPU/Power supply board removal ..... 8 - 5
I/O board assembly removal ..... 8 - 6
Display board assembly removal ..... 8 - 7
Membrane switch replacement - old case ..... 8 - 8
Membrane switch replacement - new case ..... 8 - 9
Pump assembly removal ..... 8 - 10
Motor assembly removal ..... 8 - 11
Realignment of motor coupler ..... 8 - 12
Cassette housing disassembly ..... 8 - 13
Safety clip mechanism disassembly ..... 8 - 13
Cam housing switch disassembly ..... 8 - 14
Calibration and adjustment of components ..... 8 - 15
Cam housing switch adjustment ..... 8 - 15
Occlusion alarm adjustment ..... 8 - 16
Voltage Checks ..... 8 - 18
Power supply voltage check ..... 8 - 18
Low and dead battery alarm check ..... 8 - 21

Chapter 9 - Illustrated Parts List

Illustrated Parts List for pump Serial numbers from 3000 to 60,000 ..... 9 - 1
General assembly of the volumetric pump ..... 9 - 2
Pump assembly ..... 9 - 8
Rear housing assembly ..... 9 - 9
Display board assembly ..... 9 - 12
CPU power supply/RS232 board assembly ..... 9 - 14
I/O board assembly ..... 9 - 16
Illustrated Parts List for Serial numbers from 60,000 ..... 9 - 17
General assembly of the volumetric pump ..... 9 - 18
Pump assembly ..... 9 - 22
Rear housing assembly ..... 9 - 23
Display board assembly ..... 9 - 25
CPU power supply/RS232 board assembly ..... 9 - 26
I/O board assembly ..... 9 - 27

Chapter 10 - Electrical Diagrams

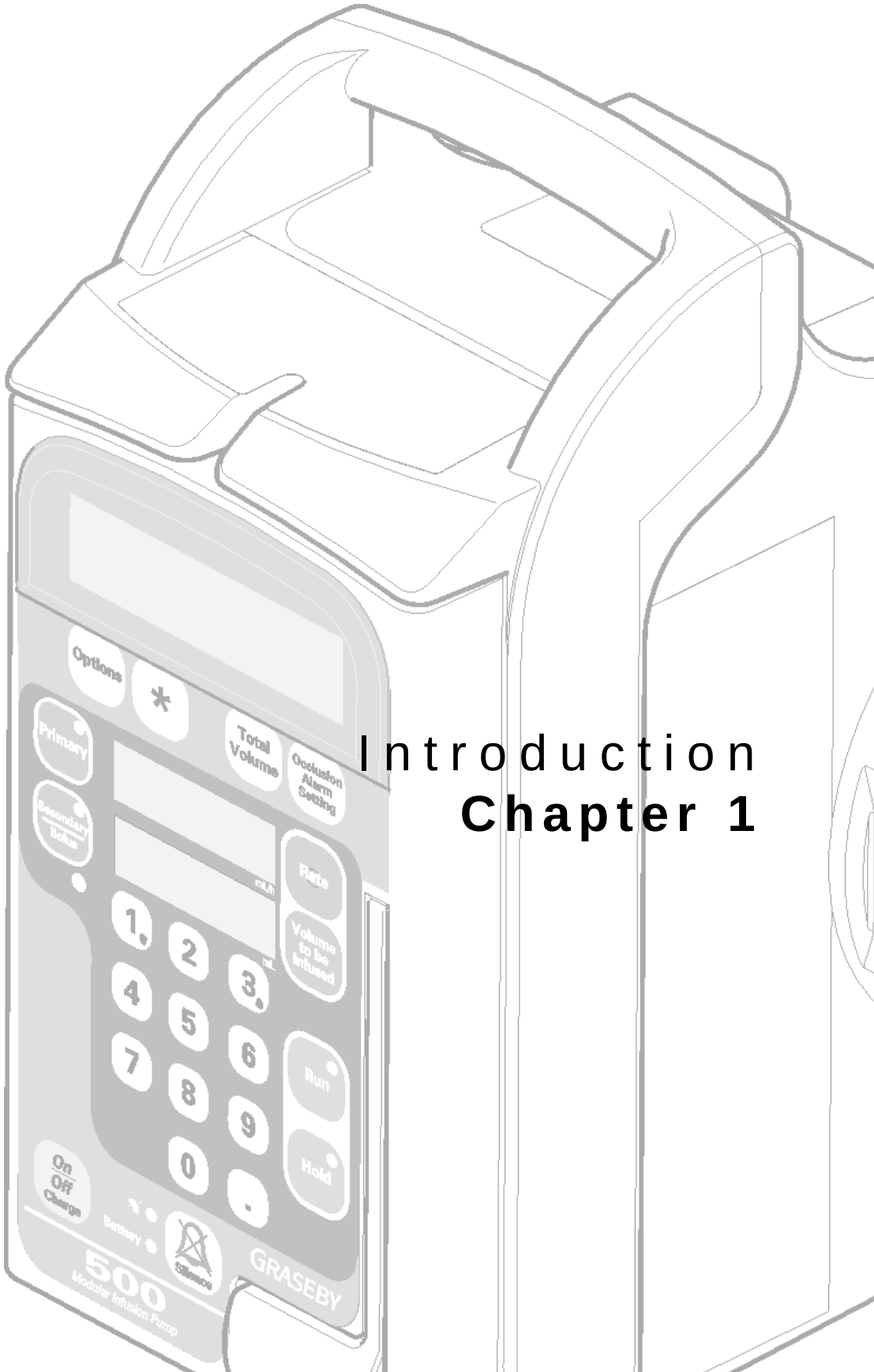
Electrical Diagrams ..... 10 - 1
Introduction ..... 10 - 1
Overall functional block diagram ..... 10 - 2
Power routeing block diagram ..... 10 - 3
Electrical routeing block diagram ..... 10 - 4
Display board schematic ..... 10 - 5
CPU/Power supply schematic (sheet 1 of 3) ..... 10 - 6
CPU/Power supply schematic - CE (sheet 2 of 3) ..... 10 - 7
CPU/Power supply circuit (sheet 3 of 3) ..... 10 -8
Input/Output schematic ..... 10 -9
RS232 schematic ..... 10 -10

Chapter 11 - Waveform Diagrams

Waveform Diagrams ..... 11 - 1
Introduction ..... 11 - 1

Chapter 12 - Remote monitoring and controlling of the pump

Remote monitoring and controlling of the pump ..... 12 - 1
Introduction ..... 12 - 1
Organisation of this chapter ..... 12 - 1
Summary of commands - Version 0.67 and below ..... 12 - 2
Protocol definition ..... 12 - 2
Record Format - Version 0.67 and below ..... 12 - 3
Command Codes ..... 12 - 3
Error Processing ..... 12 - 7
Summary of hardware connection and handshaking ..... 12 - 7
Example Commands ..... 12 - 8
Interfacing with pump software version 0.68 and above ..... 12 - 9
Model 3000/500 3100/505 Computer Interface ..... 12 - 9
Protocol Definition ..... 12 - 9
Character ..... 12 - 9
Format - version 0.68 and above ..... 12 - 10
Command Record Format - version 0.68 and above ..... 12 - 11
Return Record Format ..... 12 - 15
Command Summary ..... 12 - 18
Pump Powered Down - AC/Battery ..... 12 - 23
Exiting CI Mode - Terminated vs. Disabled ..... 12 - 23
Response Time-outs and Error Processing ..... 12 - 24
Summary of Handshaking and Hardware Connection ..... 12 - 24
Example Commands ..... 12 - 25



Introduction
Chapter 1

Introduction

Scope of this manual

This manual is aimed at service personnel to enable them to service and repair the Volumetric range of pumps. It has been revised and updated to cover the Version 0.71 pump software, and where appropriate it describes and illustrates the revised case design (for pumps with serial numbers from 60,000). However, the manual is backwards compatible with all earlier versions of pump software and case design.

Related manuals

Refer to the Instruction Manual and Technical User Manual when more detailed operating information is required, since this is outside the scope of the Service Manual. The following manuals are applicable to the Volumetric Infusion Pumps with Version 0.71 software and are listed in *Chapter 9 Illustrated Parts List*:

- Instruction Manual and Technical User Manual - old case design, see pages 9-6 and 9-7 for part numbers
- Instruction Manual and Technical User Manual - new case design, see page 9-21 for part numbers

The Instruction Manuals for Version 0.67 and earlier software are listed in the first section of *Chapter 9 Illustrated Parts List,* see page 9-6.

Graseby service contacts

If you have any queries or problems with your pump that cannot be solved by this manual, please contact the appropriate Service Centre.

UK service address

GRASEBY MEDICAL LIMITED
COLONIAL WAY
WATFORD
HERTFORDSHIRE
WD24 4LG
ENGLAND

TEL: (+44) (0)1923 246434
FAX: (+44) (0)1923 447773
Website: www.graseby.co.uk

USA service address

DELTEC INC.
1265 GREY FOX ROAD
ST PAUL
MINNESOTA
55112
U.S.A.

TEL: 001 651 633 2556
TOLL FREE 0800 433 5832
FAX: 001 651 628 7459
Website: www.deltec.com

Product Overview

1

System description

The **Model 3000/500** and **Micro 3100/505** Volumetric Infusion pumps, including the dedicated administration sets, are for use by trained medical professionals in the intravenous and intra-arterial delivery of fluid and medications. In addition, they may be used for epidural delivery.

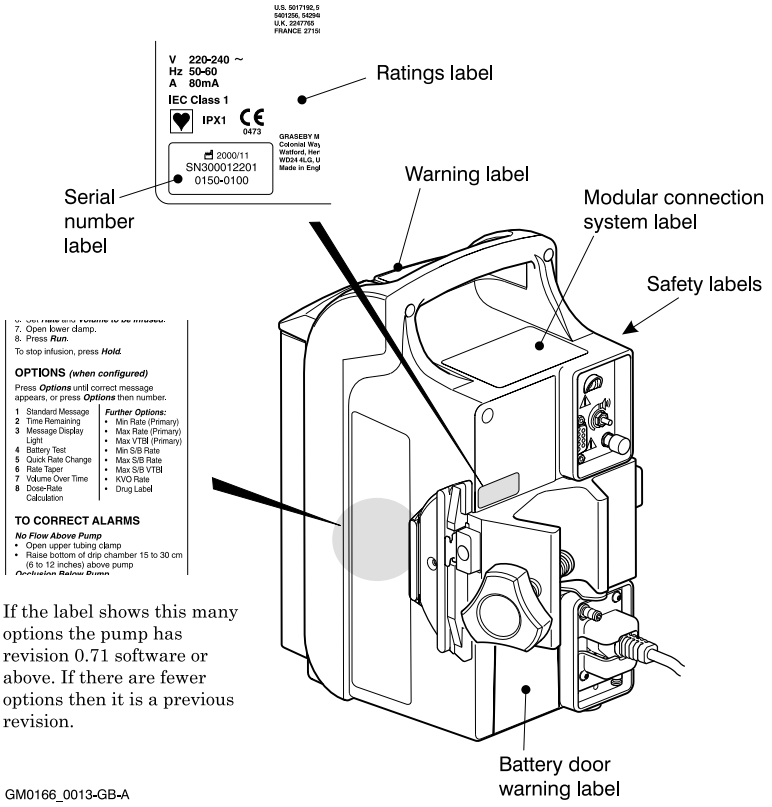
Note: Graseby Volumetric Infusion Pumps are also known as the **Model 500** and **Micro 505**. With the exception of the numbering the 3000/500 and the 3100/505 versions of the pumps are identical.

Optional labels

To assist users to differentiate the pump and IV set being used for epidural delivery, from those being used for other infusions, a yellow Epidural Label Set for the Volumetric Infusion Pump (part no. TPF-00306) is available from Graseby Medical Ltd.

Software versions

If a pump label lists more than eight options, Version 0.71 software is installed. If there are fewer options, the pump has an earlier version of software. You can find out the software version of the pump by checking on the Biomedical Menu, see *Chapter 4, Volumetric Pump Menus*.



If the label shows this many options the pump has revision 0.71 software or above. If there are fewer options then it is a previous revision.

About Version 0.71

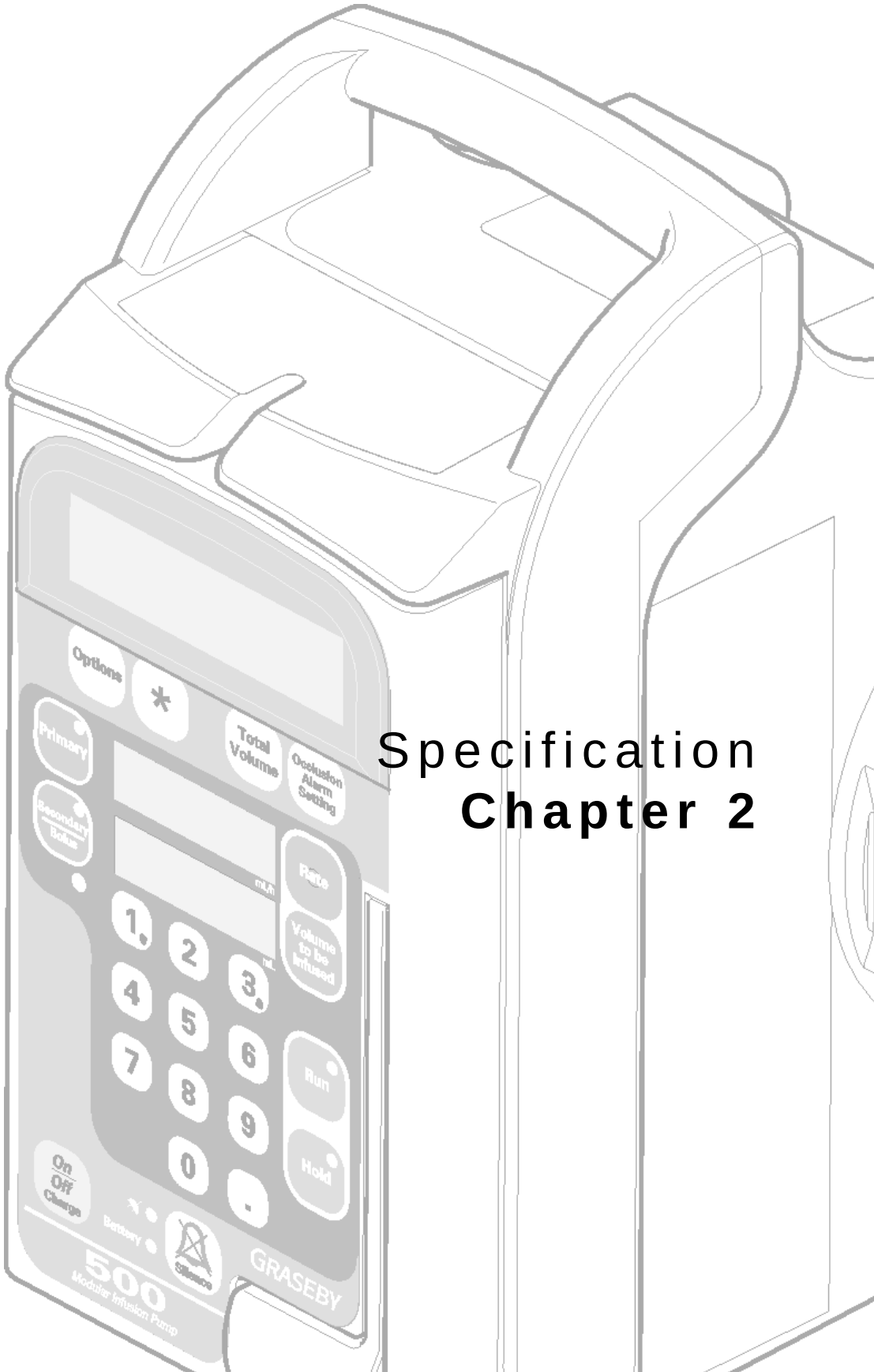
The new software contains some completely new features as well as improvements to existing features. These include many new configurable options such as selectable default settings for the occlusion alarm levels, Primary/Secondary Rate and Volume to be Infused selectable minimum and maximum limits, drug library and bolus functions. Added to this, the Quick Rate Change option is now a configurable feature, and may be enabled or disabled as required.

For a complete list of the functions please see the new Volumetric Instruction Manual and the Technical User Manual.

Upgrading to Version 0.71

It is possible to upgrade earlier Graseby Medical Volumetric range pumps to the latest software version 0.71. For 3000/500 pumps order part no. 0150-0671 and for 3100/505 pumps order part no. 0150-0672 (note these are English only kits). The upgrade kit contains the following items:

- V0.71 CPU Board Prom
- 3.66A Display Prom
- Keypad Overlay (3000/500, 3100/505)
- Keypad
- Start up Label
- Overlabel (3100/505)
- Lower door recess label
- Instruction Manual
- Technical User Manual
- Instructions for upgrade.



Specification
Chapter 2

Specifications

General

Weight	5 kg (11 pounds).
Dimensions	*for pumps with serial numbers from 3000 to 59,999* including pole clamp Height 25 cm (10 inches). Width 21.5 cm (8.6 inches). Depth 23.5 cm (9.45 inches). *for pumps with serial numbers from 60,000* including pole clamp Height 28 cm (11 inches). Width 21.5 cm (8.6 inches). Depth 23.5 cm (9.45 inches).
Temperature	Operating 18° to 40° C (64° to 104° F) Storage -25° to +55° C (-13° to 131° F).
Relative humidity	Operating 30% to 75% (non-condensing). Storage 30% to 75% (non-condensing).
Pressure range	Operating 50 kPa to 106 kPa Storage 19 kPa to 106 kPa
Immunity levels	Immunity levels are the full levels specified in EN60601-1-2 (radiated immunity is 3 V/m and ESD immunity is 3 kV contact and 8 kV air).
Free flow protection	The pump mechanism operates the safety clip on the administration set.
Head-height	*From bottom of drip chamber to top of pump*
Model 3000/500	15 cm (6 ins) minimum for flow rates <500 mL/h 30 cm (12 ins) minimum for flow rates >500 mL/h 30 cm (12 ins) when using 60 drops/mL sets 30 cm (12 ins) when using thick solutions*
Micro 3100/505	15 cm (6 ins) minimum 30 cm (12 ins) when using 60 drops/mL sets 30 cm (12 ins) when using thick solutions* * certain cytotoxic agents, lipid-based fluids and other viscous solutions, for example Total Parenteral Nutrition.

Self test	Dual microprocessors independently test each other.
Maximum over infusion	Under a single-fault condition, the maximum over infusion that may occur is 12.5% over the selected flow rate. Larger inaccuracies are detected by the pump, and cause it to stop infusing and to alarm.
Air detect system	Air bubbles are detected by electronic opto-encoder detection device (with self-checking sensors) located on cassette housing.
Accuracy	± 2% of displayed rate and volume to be infused. The quoted accuracy is ±2% for a long-term infusion. Below rates of 1 mL/h this accuracy may not be achieved for a short-term infusion. During the total infusion time the accuracy averages out (see trumpet curves in this chapter).
Accuracy measurement equipment	50 mL glass measurement burette graduated in 0.1 mL increments and traceable to National Institute of Standards and Technology or appropriate international standards bureau.
Test solution	Sterile water or normal saline at room temperature (70°F ±5°/21°C ±3°). Graseby standard (primary), 20 drops/mL, non-checkvalve administration set (8C820).
Testing conditions	
Model 3000/500	fluid level in the solution container 46 cm (18 inches) above top of the pump, rate set at 999 mL/h and volume to be infused of 49 mL.
Micro 3100/505	fluid level in the solution container 46 cm (18 inches) above top of the pump, rate set at 99.9 mL/h and volume to be infused of 25.0 mL.

Accessories

For a complete list of Administration Sets, please contact Graseby Medical or your local distributor.

Power

AC power supply	Internally configured for either 100-120 V AC, 200 mA, 50/60 Hz. or, 220-240 V AC, 80 mA, 50/60 Hz.
Battery type	Rechargeable, sealed lead-acid, 12 Volt, 1.3 Ah.
Battery operating time	6 hours at 100 mL/h (99.9 mL/h on Micro 3100/505), with approximately 1/2 hour warning of discharged battery.
Battery recharge time	Approximately 10 hours, depending on the operating conditions. The batteries will be charging during an infusion.
Leakage current	100 to 120 V less than 20 microamps ungrounded or, 220 to 240 V less than 50 microamps ungrounded This is measured between the ground stud and the earth protective prong of the AC mains connector.

Over-current protection

Voltage	AC line fuse	Thermal fuse	Battery fuse
100 to 120 V	200 mA	130°	1.0 amp
220 to 240 V	2 x 80 mA	130°	1.0 amp

Note: All fuses are time delay fuses

Primary and Secondary Infusions

Rate range

Model 3000/500	*Range*	*Increment*
	0.1 to 99.9 mL/h	0.1 mL/h
	1 to 999 mL/h	1 mL/h
Micro 3100/505	*Range*	*Increment*
	0.1 to 99.9 mL/h	0.1 mL/h

Volume to be infused

Model 3000/500	*Range*	*Increment*
	0.1 to 999.9 mL	0.1 mL
	1 to 9999 mL	1 mL
Micro 3100/505	*Range*	*Increment*
	0.1 to 999.9 mL	0.1 mL

Rate Taper Infusions

Rate range

Model 3000/500	*Range*	*Increment*
	0.1 to 99.9 mL/h	0.1 mL/h
	1 to 400 mL/h	1 mL/h
Micro 3100/505	*Range*	*Increment*
	0.1 to 99.9 mL/h	0.1 mL/h

Volume to be infused

Model 3000/500	*Range*	*Increment*
	0.1 to 999.9 mL	0.1 mL
	1 to 4400 mL	1 mL
Micro 3100/505	*Range*	*Increment*
	0.1 to 999.9 mL	0.1 mL

Time range

All pumps	*Range*	*Increment*
	0 to 59 minutes	1 minute
	0 to 48 hours	1 hour

Volume Over Time Infusions

Rate range

Model 3000/500	*Range*	*Increment*
	0.1 to 99.9 mL/h	0.1 mL/h
	1 to 999 mL/h	1 mL/h
Micro 3100/505	*Range*	*Increment*
	0.1 to 99.9 mL/h	0.1 mL/h

Volume to be infused range

Model 3000/500	*Range*	*Increment*
	0.1 to 99.9 mL	0.1 mL
	1 to 9999 mL	1 mL
Micro 3100/505	*Range*	*Increment*
	0.1 to 99.9 mL	0.1 mL
	1 to 999 mL	1 mL

Time range

All pumps	*Range*	*Increment*
	0 to 59 minutes	1 minute
	0 to 48 hours	1 hour

Dose-Rate Calculation Infusions:

Dose range

	Range	*Increment*
	0.01 to 99.99	0.01
	0.1 to 999.9	0.1
	1 to 9999	1

Body weight range

Units	*Range*	*Increment*
Kilograms (kg)	0.10 to 99.99 kg	0.01 kg
	0.1 to 453 kg	0.1 kg
Pounds (lbs)	0.22 to 99.99 lbs	0.01 lbs
	0.2 to 999 lbs	0.1 lb.

Drug amount modes/range

Mode	*Range*	*Increment*
MG drug/bag	0.01 to 99.99	0.01
	0.1 to 999.9	0.1
	1 to 99999	1
Gm drug/bag	0.01 to 99.99	0.01
	0.1 to 99.9	0.1
	1 to 999	1
mcg drug/bag	0.01 to 9.99	0.01
	0.1 to 99.9	0.1
	1 to 9999	1
units/bag	0.01 to 99.99	0.01
	0.1 to 999.9	0.1
	1 to 99999	1

Rate range

Model 3000/500	*Range*	*Increment*
	0.1 to 99.9 mL/h	0.1 mL/h
	1 to 999 mL/h	1 mL/h
Micro 3100/505	*Range*	*Increment*
	0.1 to 99.9 mL/h	0.1 mL/h

Volume to be infused range

Model 3000/500	*Range*	*Increment*
	0.1 to 999.9 mL	0.1 mL
	1 to 9999 mL	1 mL
Micro 3100/505	*Range*	*Increment*
	0.1 to 999.9 mL	0.1 mL

Occlusion sensing

Alarm levels *(approximate values)*

Pressure units	Low	Medium	High
mmHg	103 mmHg	259 mmHg	517 mmHg
psi	2 psi	5 psi	10 psi
kPa	13.5 kPa	34.5 kPa	68.9 kPa

Time to occlusion

This table shows the maximum (measured +25%) delay times for activation of the "**Occlusion below pump**" alarm:

Rate	*Low Occlusion setting max time to alarm*	*High occlusion setting max time to alarm*
1 mL/h	11 min, 5 sec.	1 hour, 10 min.
25 mL/h	15 sec.	2 min, 35 sec.

KVO rate

Default KVO rate

3.0 mL/h, or at the programmed rate if set at less than these values.

Configurable KVO rates *(Version 0.71 software and above)*

Model 3000/500	0.1 to 10.0 mL/h
Micro 3100/505	0.1 to 3.0 mL/h

Symbols used on the pump

Front panel symbols

Battery is charging/mains power applied.

Audio alarm silence button.

Side panel symbols

Use pump only in upright position.

Rear panel symbols

Attention: consult accompanying documents.

Data input/output.

CF Application (cardiac floating)

Audio alarm volume control.

Alternating current.

Nurse call option (only if option is fitted)

Inside battery door symbols

Attention: dangerous voltages, risk of electric shock if the housing is opened.

Equipotential point.

Internal battery.

Dispose of in an environmentally safe manner.

Battery symbols

Recycle battery

Dispose of in an environmentally safe manner.

Standards

Electrical Safety

Classified as Internally Powered Equipment
Class 1, Type CF (Cardiac Floating) insulation on all inputs.

Design Standards

EN 60601-1, EN 60601-1-2, IEC 601-2-24 (Draft).

Fluid Ingress Protection

IPX 1 Drip proof

CE Marking

The CE mark demonstrates that the pump conforms to the requirements in the European Council Directive 93/42/EEC concerning medical devices.

The number 0473 identifies the Notified Body under which the Quality Systems operated within Graseby Medical Ltd are assessed.

Disposal

When the time comes to dispose of the pump, its batteries, or any of its accessories, do so in the best way to minimise any negative impact on the environment.

You may be able to use special recycling or disposal schemes. To find out about these contact your local waste disposal service. Separate any other parts of the equipment where arrangements can be made for their recovery, either by recycling or energy recovery.

Important: Existing national or local regulations concerning waste disposal must take precedence over the above advice.

Patents

USA	5401256	*GB*	2247765
	5103214	*France*	2715073
	5429485		
	5017192		

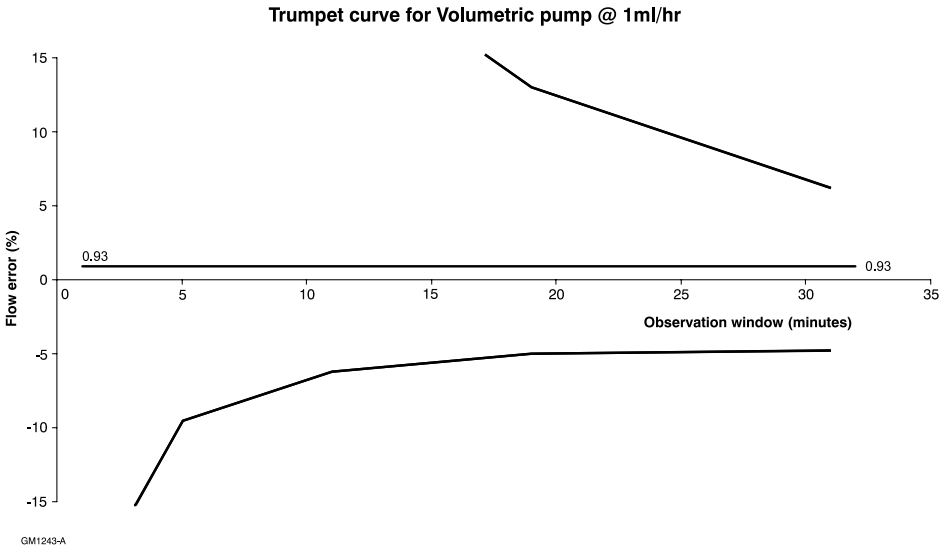
Trumpet curves

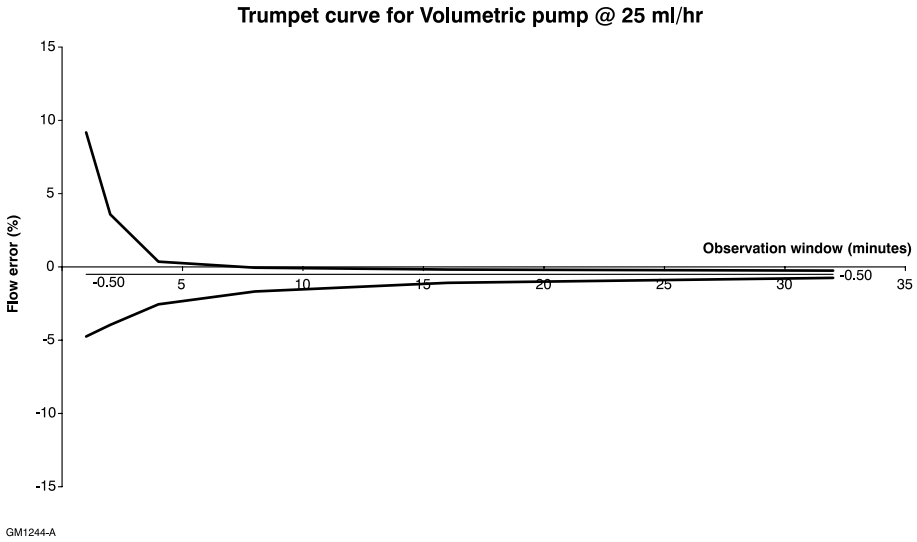
The curves were developed while testing the **Model 3000/500** using a *Graseby Standard Adult Set, 8C-820* administration set.

The curves for the **Micro 3100/505** are identical since both pumps have the same pumping mechanism.

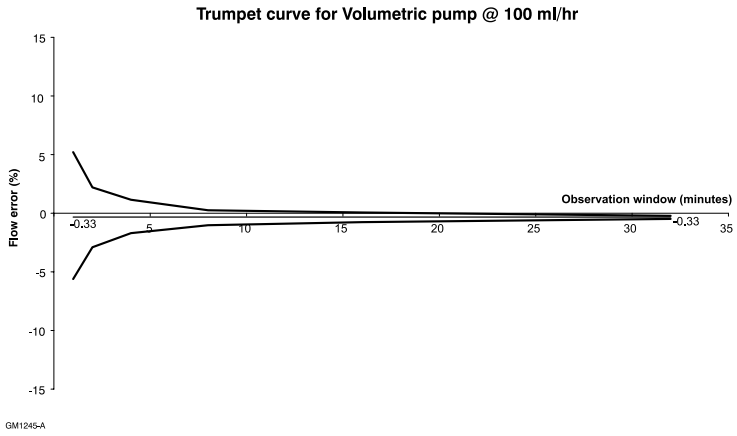
The trumpet curve represents the worst-case rate error in any given observation window over the whole infusion period.

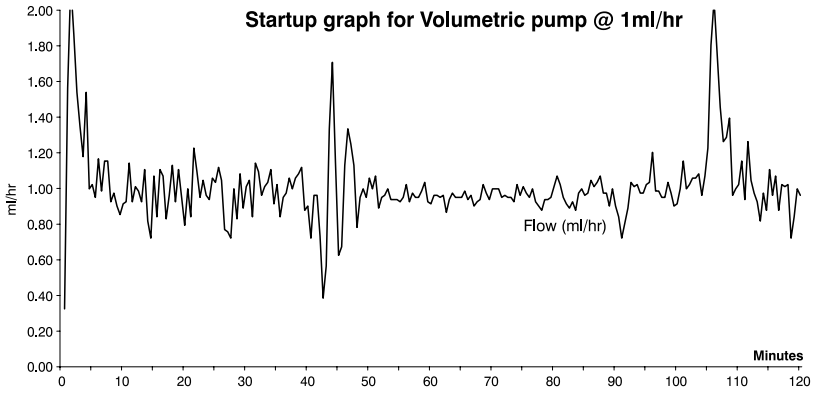
These trumpet curves were prepared according to the requirements of IEC 601-2-24.

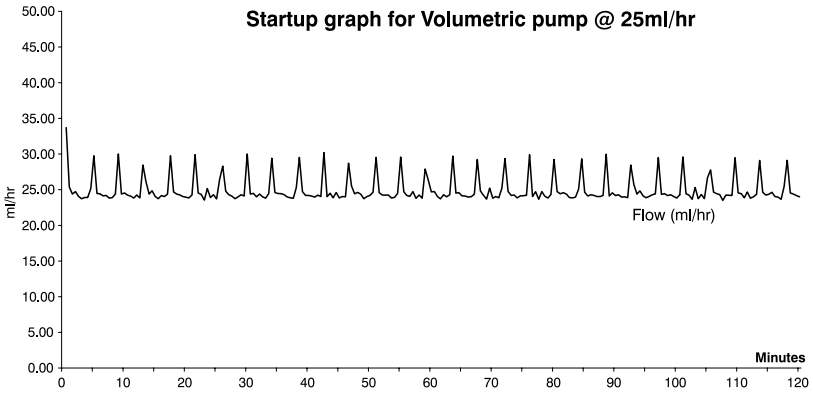


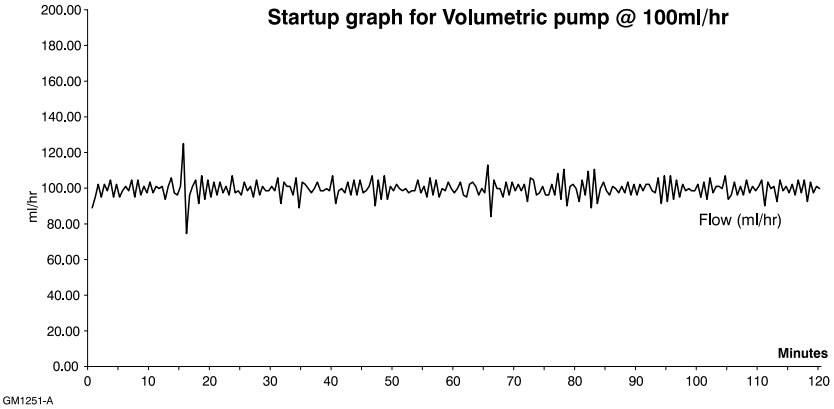


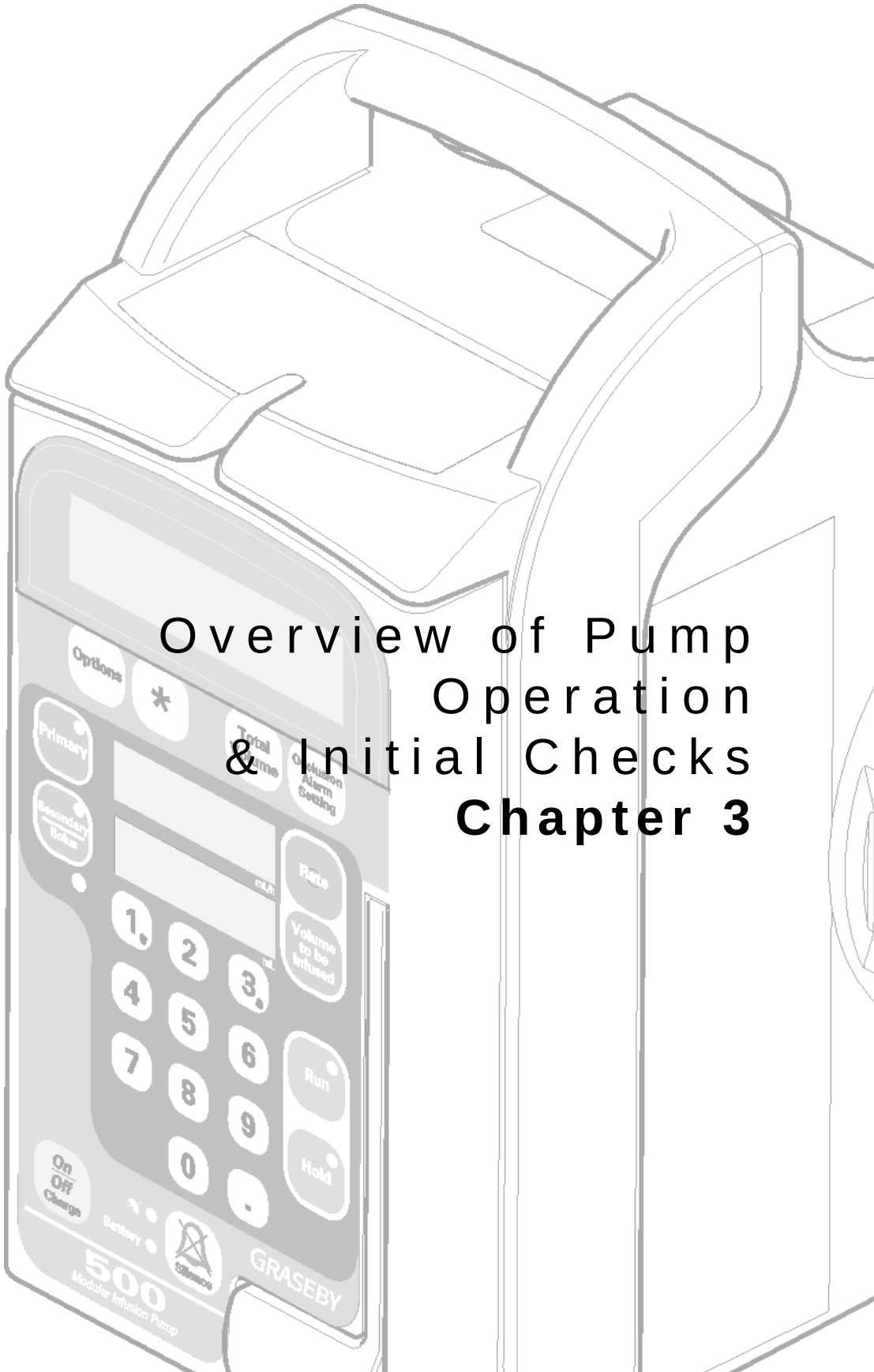
2


Trumpet curve for Volumetric pump @ 100 ml/hr
Flow error (%)
Observation window (minutes)
-0.33
-0.33
GM1245-A


Startup graph for Volumetric pump @ 1ml/hr
ml/hr
Flow (ml/hr)
Minutes


Startup graph for Volumetric pump @ 25ml/hr
ml/hr
Flow (ml/hr)
Minutes


Startup graph for Volumetric pump @ 100ml/hr
ml/hr
Flow (ml/hr)
Minutes
GM1251-A



Overview of Pump Operation & Initial Checks

Chapter 3

Overview of Pump Operation & Initial Checks

This chapter provides an introduction to the Volumetric pump. It gives an overview of:

- The exterior of the pump (the revised case design is shown)
- How the pump is powered
- How the pump works
- Power up - tests and checks
- Powering down
- Power monitoring and battery testing
- Alarms and alerts.

The revised case design is shown on the diagrams on the next three pages, but the keys, indicators and displays apply equally to the original Volumetric case design.

Finding further information

Detailed information about the topics covered in this chapter may be found later in this manual: Chapter 5 through Chapter 9.

The menus that allow the configuration of the pump are described in Chapter 4.

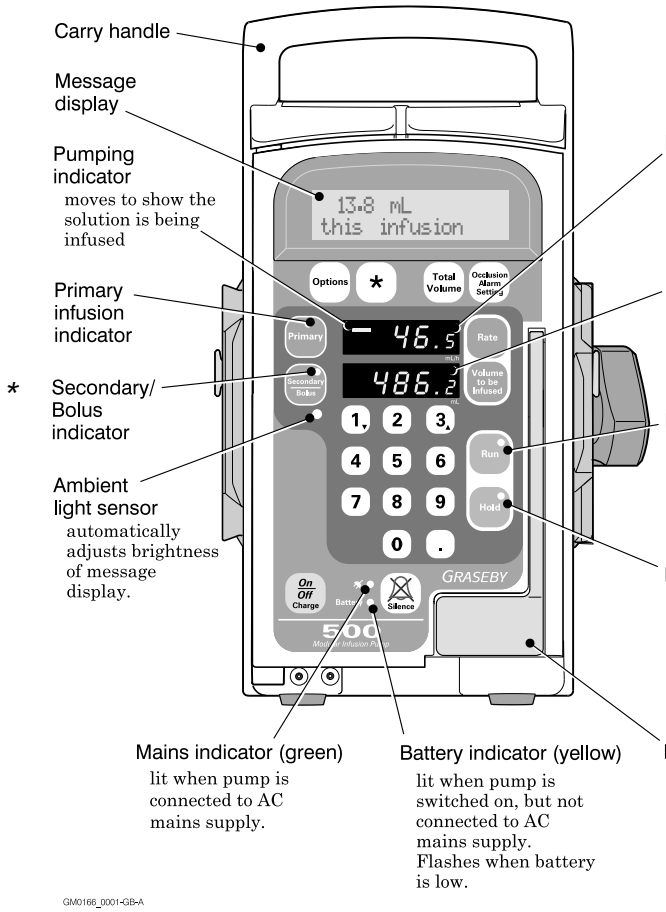
Troubleshooting is described in Chapter 7 page 17.

Note: If you want to find out how to use the pump, you must read the Instruction and Technical User Manuals. It contains not only the full instructions, but also all the warnings and cautions that must be followed for the safe use of the pump.

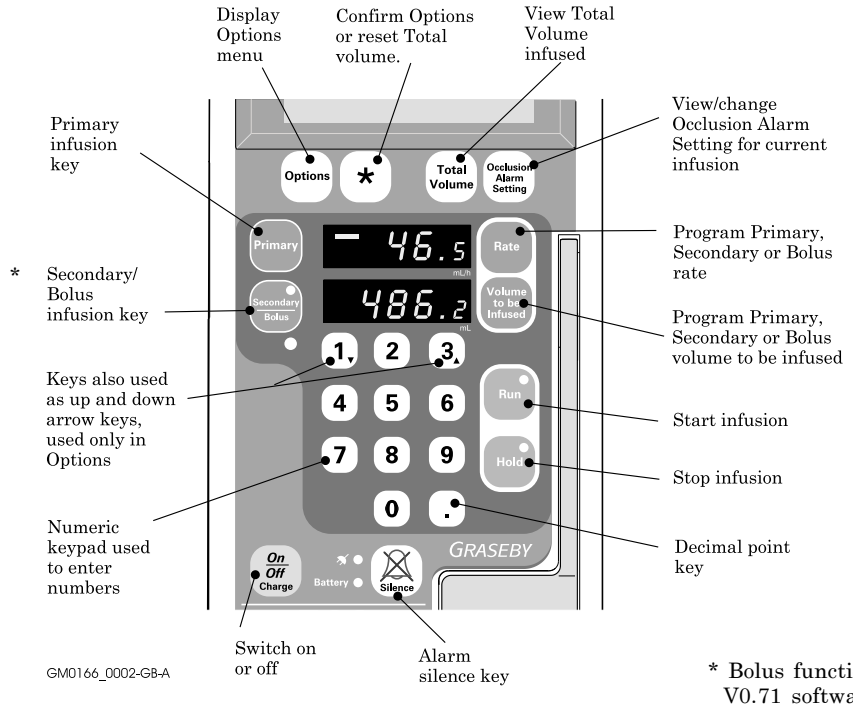
3

Exterior of the 500/3000 pump - front (Revised case design shown here)

Indicators and displays


Carry handle
Message display
Pumping indicator
moves to show the solution is being infused
Primary infusion indicator
* Secondary/ Bolus indicator
Ambient light sensor
automatically adjusts brightness of message display.
13.8 mL this infusion
Options
Total Volume
Occlusion Alarm Setting
Primary
Secondary Bolus
Rate
Volume to be Infused
Run
Hold
On Off Charge
Battery
Silence
GRASEBY
Rate display
for Primary, Secondary or Bolus infusion, depending on indicator.
Volume display
for Primary, Secondary or Bolus infusion, depending on indicator.
Run
indicator ON when pump is infusing. Flashing when infusing at KVO rate.
Hold
indicator ON when pump is not infusing. Flashing when alarm sounds.
Mains indicator (green)
lit when pump is connected to AC mains supply.
Battery indicator (yellow)
lit when pump is switched on, but not connected to AC mains supply. Flashes when battery is low.
Door latch
pull the latch up and out to switch pump on and open door for loading. Swing door closed and push the latch in to secure the door.
GM0166_0001-GB-A

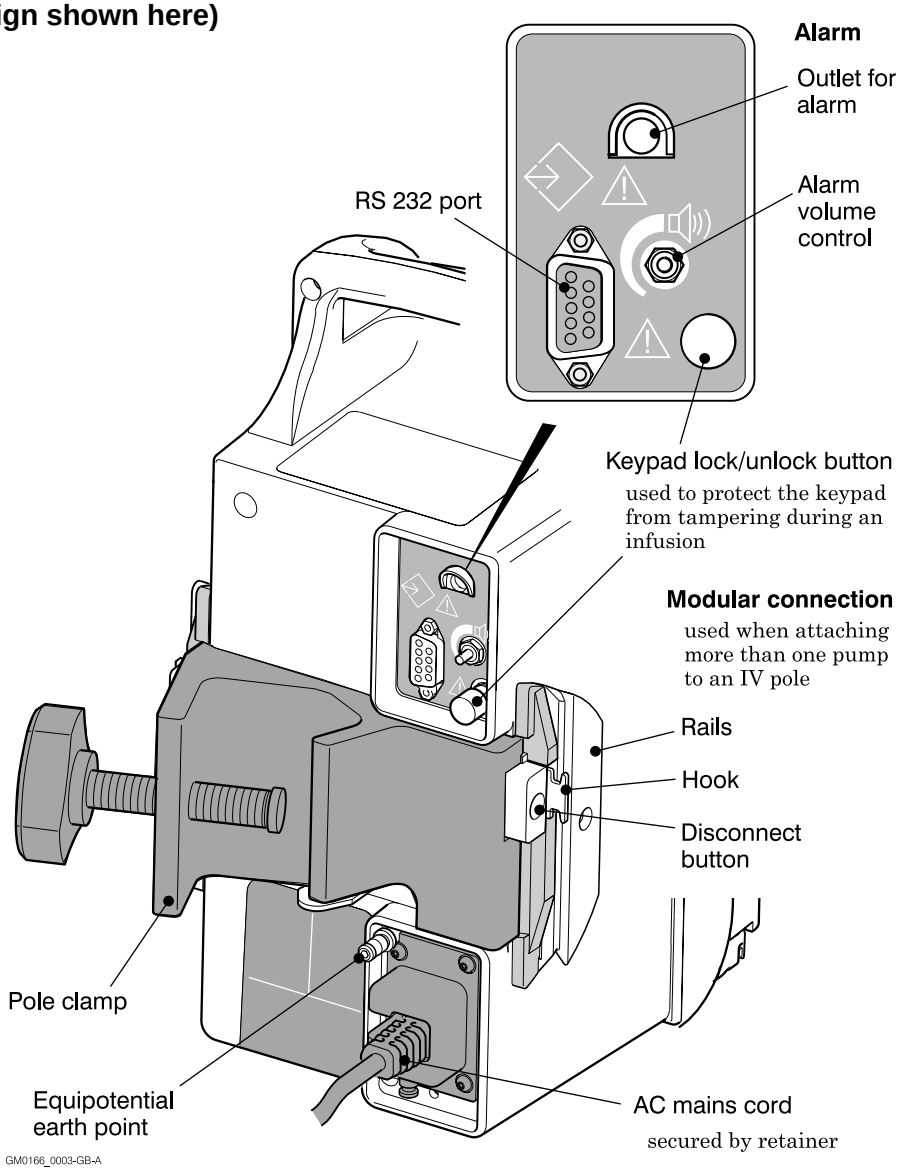
Programming keys



* Bolus function available on V0.71 software only

Exterior of the pump - rear

(Revised case design shown here)



How the pump is powered

The pump can be powered in two ways, either:

- AC power connection
- Battery operation, for backup, or portable operation.

AC power connection

The pumps are equipped with a detachable power cord, which has a three-prong, hospital grade plug. The power cord is designed to minimise leakage current inducing potentials on the ground wire.

The power cord is secured to the rear housing, but can be removed if safety testing of the cord becomes necessary. A cord retainer is attached over the cord by four screws. The cord retainer must be reinstalled whenever the cord is reattached or replaced, or ground and power connections may become unreliable.

If the cord is damaged, replace it immediately. Replacements should be made using original equipment in order to maintain grounding safety and an acceptable level of leakage current. Integrity of the three-prong plug is also important to prevent electric shock. Do not use extension cords, adapter plugs, or attempt to defeat the plug's ground connection. Always hold the plug itself when unplugging the power cord, as pulling on the cord could damage plug connections.

Battery and portable operation

The pumps contain a rechargeable 12 volt battery for portable operation, or if AC power fails or is unavailable. Monitoring and testing the battery is described on page 3-13.

The infusion pumps may be operated while standing on any flat surface, provided the bottom of the administration set drip chamber is at least 15 cm (6 inches) above the top of the pump.

On Model 3000/500, 30 cm (12 inches) may be required for rates over 500 mL/h. On both Model 500 and Micro 505, 30 cm (12 inches) may be required when using thick solutions and/or 60 drops/mL sets.

Typically, however, the pump is attached to an IV pole using the pole clamp on the rear housing. IV pole mounting and battery operation make the pumps portable for patient mobility.

When multiple infusion lines are required, you can connect up to three pumps to a single pole using the hooks and rails that make up the modular connection system. As all pumps have connectors on both sides, you can use any one as the centre, left, or right pump.

How the pump works

This section provides a overview of how the pump works. Further details are provided in Chapters 5 to 8.

For details of how to use the pump, refer to the *Instruction Manual* and the *Technical User Manual*.

Microprocessors

The pumps contain a central system control microprocessor (CPU1), with two peripheral microprocessors used for display control (CPU3) and fail-safe system monitoring (CPU2). The central microprocessor controls all user programmable functions, alarm condition sensors, and inter-processor communications.

Pumping mechanism

The central microprocessor also controls a 4-phase stepping motor which is used to operate the pumping mechanism. Smooth fluid delivery is accomplished by uninterrupted forward rotation of the pumping mechanism when the pump is running.

Door latch open

Pulling the door latch handle open moves the cam housing and pumping mechanism to the ***load position***. The pistons are best positioned to accept a fluid filled cassette when in the ***load position***.

When the door is opened to turn the pump on, or if the door is opened while the pump is powering up, the hold light does not turn on until the motor has backed off to its load position.

Door latch closed

Pushing the door latch closed moves the pumping mechanism to the ***operate position***.

Completion of cassette loading results in some additional reverse rotation of the motor as pressure (which develops during the loading process) on the cassette is reduced and the pumping mechanism prepares for delivery. To allow up-line pressure release, the over pressure valve seals the lower fluid pathway during reverse rotation of the pumping mechanism and reopens upon initial forward rotation.

Free flow prevention system - safety clip

The Free-Flow Prevention System consists of the Safety Clip (located under the cassette on the administration set) and the mechanical clip retention slot and associated mechanics on the lower cassette housing. The Safety Clip must be placed in the retention slot when loading the cassette, or the pump will not operate.

- When the door is closed the Safety Clip opens to allow fluid delivery.
- When the door is opened, the Safety Clip closes, preventing unrestricted gravity flow even when the administration set is removed from the pump.

Pressure / occlusion monitoring

Downline pressure is developed by the pumping pistons at the upper and middle cassette chambers, and is continuously monitored at the middle cassette chamber.

Occlusion monitoring is performed by the pressure transducer mounted in the door. The Occlusion alarm is activated if pressure exceeds the user selected threshold level. The pump briefly backs off to reduce downline pressure, which minimizes fluid bolus to the patient. At that point, the pump stops and fluid delivery ceases.

Pumps with revision 0.64 and higher software

In the Medium or High Occlusion Alarm Settings, when downline pressure exceeds the selected threshold, the motor pauses (***Run*** remains lit), and the pumping indicator stops. If, within 10 seconds, the pressure drops back below the threshold, then pumping resumes and no alarm is sounded (if pressure remains high, the "**Occlusion below pump**" alarm is activated). If repeated pressure spikes occur, causing the pump to enter the filtering process for a total of 30 seconds, measured over the last 4 minutes the pump was infusing, the alarm also sounds. Occlusions detected in the Low Occlusion Alarm Setting cause an immediate alarm.

Message Display

The Message Display is an alphanumeric liquid crystal display, consisting of 2 lines by 16 characters. It shows infusion status, visual alarms, options, and other messages.

When the pump is running, some messages are displayed briefly, then the display reverts to the standard message. The general rule is: informational messages are displayed for 5 seconds; messages with instructions or which require input are displayed for 10 seconds. Pressing a key which has a different display associated with it causes its screen to be instantly displayed before the 5 or 10 second timeout expires on the first message.

Numeric Displays

During operation, the rate and volume to be infused are continuously shown in the numeric displays. The Message Display shows the volume infused for the current infusion as fluid is delivered, and the volume to be infused display counts down as the volume in the Message Display counts up. Also, appropriate status lights are lit to show the current status of the pump.

Numeric and Message Display Memory

When the pump is turned off, data in the Message Display and numeric displays are stored in nonvolatile memory and displayed again when the pump is turned on. The memory is maintained by a 3 volt lithium battery integrated with the memory chip.

Backlight for Message Display

The Message Display is backlit when any key is pressed, and when the door is opened. The backlight will remain on for approximately 1 minute. The backlight timeout feature has different characteristics when the pump is on AC power and battery power.

Backlight on AC

With the pump on hold, and with the door closed, the backlight will always be on. With the pump on hold, and with the door open, the backlight will timeout after approximately 1 minute. After timeout, if the door is closed, the Message Display backlight will turn on.

Backlight on Battery

When on battery power, the backlight will timeout after approximately 1 minute whether the door is open or closed.

Backlight during an alarm or alert

During an alarm or alert, the backlight flashes on and off with the audible alarms and remains on after the audio has been silenced.

Analog to digital monitoring

In addition to controlling the Message Display, numeric displays, and LEDs, the display software monitors a number of analog to digital conversion values. These are:

- Pressure
- Battery level
- Cassette position
- Ambient lighting level
- LED/segment forward voltage drops. The LED/segment voltage drops are checked during power-up.

Pressure, battery, light and cassette monitoring

A CPU periodically checks the current analog levels for the pressure sensor input, the battery level, the pressure plate position input, and the photo sensor used to measure ambient lighting. These levels are each measured at least once per second, and their values (0-255) are accessible to the on-board CPUs. Decisions based on sensor readings require at least two reads of the sensor.

- The pressure sensor input is used to check for occlusions.
- The pressure plate position switch indicates whether the cassette is in place.
- The battery level input is used to check for low battery levels, or when a battery test is initiated. Low battery levels result in appropriate alarm messages.
- The ambient lighting level input is used to adjust the intensity of LEDs based on the current room lighting.

LED/segment monitoring

The Display board CPU periodically (once per second) checks the status of each individual LED and digit segment. If an LED or segment should be off, it is checked to make sure there is no forward voltage drop. If there is supposed to be a forward voltage drop and it is absent, or it is outside the acceptable range a fault is reported to the on-board CPUs and a System Error alarm message appears in the Message Display.

Power up tests and checks

This section explains the sequence of the pump's internal initialisation tests and checks carried out on a 'Cold boot' which takes place if the ***On/Off*** key is pressed, or the door is opened whilst the pump is switched off.

The end of this section describes what happens during a 'Warm boot', which takes place if the microprocessor is reset when the pump is already switched on.

Cold boot

When the pump is turned on, the ***cold boot*** sequence is as follows:

- The I/O ports of the microprocessors are initialised, placing all system components in the start up configuration.
- A write/read back test is performed on non-volatile RAM. If this test fails, the following message is displayed and the software is locked allowing no further processing:

  ```
  System Error:
  No NV RAM
  ```

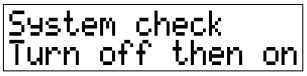
  If the pump is plugged into AC power, the message remains until the pump is unplugged. If being powered by the battery, the message is displayed for 5 seconds, then the pump automatically turns off.
- A checksum comparison is performed on non-volatile RAM, and, if it fails, system warning 13 is recorded for viewing in Biomedical Special Functions. A memory location is then checked to determine if the initialization was from a cold-boot or warm boot.
- All CPU RAM locations are cleared.
- The main CPU computes a checksum of its ROM contents and compares this against a predetermined value. If a ROM checksum error occurs, the following message is displayed, and the software is locked allowing no further processing:

  ```
  System Error:
  ROM Checksum
  ```

  If the pump is plugged into AC power, the message remains until the pump is unplugged. If being powered by the battery, the message is displayed for 5 seconds, then the pump automatically turns off.
- Timers, counters, registers, and interrupts are initialised for operation.
- Counters and timers are initialised for pump history information.
- A jumper wire is detected, thus determining whether the pump is micro/macro (Model 500/3000) or micro only (Micro 505/3100).

Communication is established between the CPUs. Commands are exchanged signalling that initialization is completed and ROM checksums are correct.

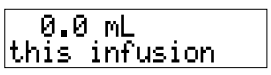
- The keypad is scanned to determine whether ***Options*** was pressed along with ***On/Off***. If so, the pump enters Biomedical Menu.
- The keypad is scanned to determine whether ***Silence*** was pressed along with ***On/Off***. If so, the pump activates "Quiet Pump" operation.
- A display test is run. The numeric displays illuminate the number 8 in each digit with decimal points active. While the numeric displays are showing 8's, the pumping motion LEDs display the number 8, then go blank. The message display briefly shows a checker-board pattern.
- The microprocessor checks to see if the pump is operating on AC power or battery. If on AC power, the charge light is already lit. If on battery power, the battery light illuminates, and the battery voltage is checked to see if it is in operating range (> 11.6 V DC). If the voltage is out of range (11.6 V DC), the low battery alarm appears. See *Power Monitoring*, page 3-13.
- The motor monitor microprocessor runs a motor cut-off test to verify proper function of the motor driver shut off. If the motor driver shut off is not working, a system warning is noted. Cold boot stops, a snapshot is taken, and the following system warning is displayed:



- If the motor driver shut off is working, the cold boot continues and the motor is backed off to its home position.
- Primary parameters are retrieved from memory and displayed. Secondary parameters are stored and ready for display. Secondary volume to be infused defaults to zero and must be re-entered.

Successful completion of cold boot

- A value is written in non-volatile memory as an indicator that a cold boot process was completed.
- The pump enters hold. Unless it was previously switched off in a special infusion mode, for example, Rate Taper, or Dose-Rate Calculation (recovery) mode, the standard message is displayed, indicating that initialisation tests and checks are complete:



End of cold boot - special infusion modes

If the pump was turned off in a special infusion mode, the standard message is not displayed. Instead, the pump shows a screen indicating the infusion mode, for example, with a Rate Taper program set (but not delivered), the message display is:

```
RUN to infuse
* Resets Taper
```

If the pump was turned off during or after running a Rate Taper program, the display will be:

```
Taper       23 mL
this infusion
```

If the pump was switched off after programming a Dose-Rate Calculation infusion, and the Dose-Rate Calculation Recovery parameter is enabled in the Technician Menu, then the display will be:

```
RUN to infuse
* Reviews Dosing
```

Warm boot

A warm boot occurs if the microprocessor is reset when the pump is already powered up. If a reset occurs the pump begins its power up initialization routine. During the power up routine, the microprocessor looks for a value in non-volatile memory normally stored during the pump's power down routine. Since the normal power down routine is not completed during a reset, the value is not found and the current routine is considered a warm boot.

The rate display shows 0.1 and the volume to be infused display shows 0.0 if a RAM checksum failure occurs.

If a warm boot occurs, the ***insistent*** audio alarm sounds, and a system warning is displayed:

```
System check
Turn off then on
```

Powering down

This section explains what happens when the pump is powered down (switched off). It describes:

- Manual power down, when the On/Off key is pressed
- Automatic power down, which occurs when the pump has been left on and alarming for 72 hours, or if the battery voltage becomes too low.

Manual power down

The pump can only be turned off by pressing ***On/Off*** while the door is closed. If the pump is running, you must first press ***Hold***, then ***On/Off.***

The master CPU stops pumping operations and all system components are disabled. The non-volatile memory is updated with checksums. At this point, if the pump is on AC power, it will continue to keep track of AC on time for pump history. The green charge light is lit, indicating that the battery is charging. If powered by battery, a non-volatile memory location is initialised, indicating power down has occurred, after which the pump turns off.

If the pump is operating on battery power, and if the pump is stuck in a fault mode where the CPU's are not operating properly, a special command (OFFCPU2) allows ***On/Off*** to operate.

If the pump is connected to AC power, turned off, and the cord is then unplugged, the pump powers down completely after writing data to pump history.

Automatic power down

If the pump is left on hold (following an alarm, or if left idle) for approximately 2 minutes with the door closed, the ***insistent*** audio alarm sounds. If the pump is left on hold with the door open, the pump alarms after approximately 6 minutes. In either case, if left alarming for 72 hours, the pump automatically shuts off.

If the battery status in the Message Display indicates:

```
Battery too low
Plug in cord
```

the pump enters hold (if running), sounds the ***insistent*** audio alarm, and the hold light flashes. If left alarming, the pump will automatically turn off in 15 minutes, or when the battery reduces to 10 volts.

Power monitoring

On AC Mains

If the pump is plugged in, the charge light is steadily lit. Software also records and stores in the pump history the period of time that the pump is plugged in.

Note: If the pump is switched off and connnected to AC power and the saftey keypad lockout feature is active, the pump cannot be switched on via the keypad, see *Instruction Manual, Security on the pump*.

On battery power

If there is a dropout in the voltage regulator due to AC line or component failure, the pump automatically switches to battery power. The battery light is steadily lit (unless the battery is low or dead, in which case it flashes), the charge light is off, and the period of time on battery is recorded and stored in the pump history.

Battery voltage levels are determined by:

Normal operating voltage:	Voltage > 11.6, ± 0.2 V DC.
Low battery:	11.0 < Voltage ≤ 11.6, ± 0.2 V DC.
Dead battery:	10.0 < Voltage ≤ 11.0, ± 0.2 V DC.
Automatic Turn Off:	Voltage < 10.0, ± 0.2 V DC.

Once a low battery state occurs (low battery, dead battery, or automatic turn off) it remains in that state unless:

- The pump is plugged in to AC power,
- The voltage drops to a level consistent with another state, or
- The pump is turned off, then on.

When the pump is turned on, on battery power, with Version 0.71 software loaded, the pump automatically carries out the battery test described in the next section.

Testing the battery

When the pump is powered on, the battery is always tested. In addition, the ***Options*** key provides access to the Battery Test option so that the approximate battery voltage can be tested without powering down the pump.

To run the Battery Test:

1. With the pump powered up, disconnect from the AC mains supply and press ***Hold***.
2. Press the ***Options*** key then ***4***, or press ***Options*** until the following message is displayed:

```
Battery test
Press * to begin
```

3. Press the ✱ key to start the test. The pump turns on all LEDs, and the rate and volume to be infused displays all zeros to form a known battery load.

The pump then measures the battery voltage. After five seconds the battery gauge displays the approximate battery capacity.

For example, this display would indicate a battery about half charged:

```
+++++++
LOW battery FULL
```


Each + indicates increasing battery voltage, as follows:

11.1	+
11.2	+
11.3	++
11.4	+++
11.5	++++
11.6	+++++
11.7	++++++
11.8	++++++++
11.9	+++++++++
12.0	++++++++++
12.1	+++++++++++++
12.2	++++++++++++++++

The display below indicates a fully charged battery:

```
++++++++++++++++
LOW battery FULL
```

If the battery capacity is low, you must connect the pump to the AC mains supply to recharge the battery.

It is possible to get a false reading if the battery is in poor condition. A new, fully charged battery operates the pump for approximately six hours at 100 ml/hr (99.9 mL/h on Micro 505).

The test described above is also carried out automatically when a pump loaded with Version 0.71 software (or later) is switched on, on battery power.

WARNING: Correct management of battery charging, as described in this documentation is essential to ensure that the pump can operate on battery for the time specified. Failure to do so may result in compromised function of the product or patient injury.

Alarms

This section explains the three different types of alarms made by the pump.

- insistent
- non-insistent
- continuous (backup alarm).

If more than one alarm condition exists simultaneously, ***insistent*** alarms take precedence over ***non-insistent*** alarms.

When an alarm condition occurs, the red Hold light illuminates and flashes at 1 Hz. The Message Display flashes with the alarm and an error or alarm message is displayed.

When the audio alarm is silenced, the hold light stops flashing and the Message Display remains lit with the alarm message displayed.

Software Version 0.67 and earlier

When a pump displaying the “Battery too low - Plug in cord” message is connected to the AC mains supply, the unit will stop alarming, if not previously stopped using the ***Silence*** or ***Hold*** key. The unit is on ***Hold***, and the Hold LED is on. However, the Message Display does not show the “On Hold” message and the associated insistent alarm is not sounded. To continue the infusion, the operator must press the ***Run*** key.

Insistent alarm

This type of alarm indicates that fluid delivery has stopped, or cannot be started.

The insistent audio alarm consists of three tones: two high pitched and one low pitched, repeated at two-second intervals. (High/high/low chime).

To silence an insistent alarm, press the ***Silence*** or ***Hold*** key. The alarm will recur unless the problem is corrected.

If an insistent alarm condition is detected, the microprocessor stops the pump and sounds the ***insistent*** audio alarm. One of the following messages is displayed:

- Air in cassette
- Battery too low
- Close clamp! Load Safety Clip
- Door open
- Loading problem. Check tubing set
- No flow above pump
- Occlusion below pump
- On Hold
- Secondary Complete
- Preset limits exceeded.

Non-insistent alarm

This type of alarm indicates that there is a condition requiring attention which has not caused the infusion to stop. For example, if the pump is running on batteries and the batteries are low, or if the infusion has switched to a KVO rate.

The non-insistent audio alarm consists of two tones, one high pitched and one low pitched, repeated at two second intervals. (High/low chime.)

In KVO, the green run light flashes at 1 Hz with 50% duty cycle. In low battery, the yellow battery light flashes at 1 Hz with 50% duty cycle.

To silence this type of alarm, press the ***Silence*** or ***Run*** key to silence the alarm without stopping fluid delivery, or press the ***Hold*** key to silence the alarm and stop fluid delivery.

Detection of the following alert conditions cause the microprocessor to sound the ***non-insistent*** audio alarm:

- Dose setup not completed
- Dose change not completed
- Dose change not accepted
- KVO *xxx* mL this infusion
- Low battery. Plug in cord
- Rate change not completed
- Secondary was set.

Continuous - backup alarm

In addition to the insistent and non-insistent operational alarms, the Volumetric pump has a fail-safe backup alarm system. This has a distinctive high-pitched tone:

- Should the audio alarm system fail, then the pump sounds the backup alarm, with a 1.5 second pause between alarm tones;
- Should an electromechanical system failure occur, the pump sounds the backup alarm continuously.

The pump displays one of these messages when sounding the backup alarm:

- Pump needs service
- System check. Turn off then on.

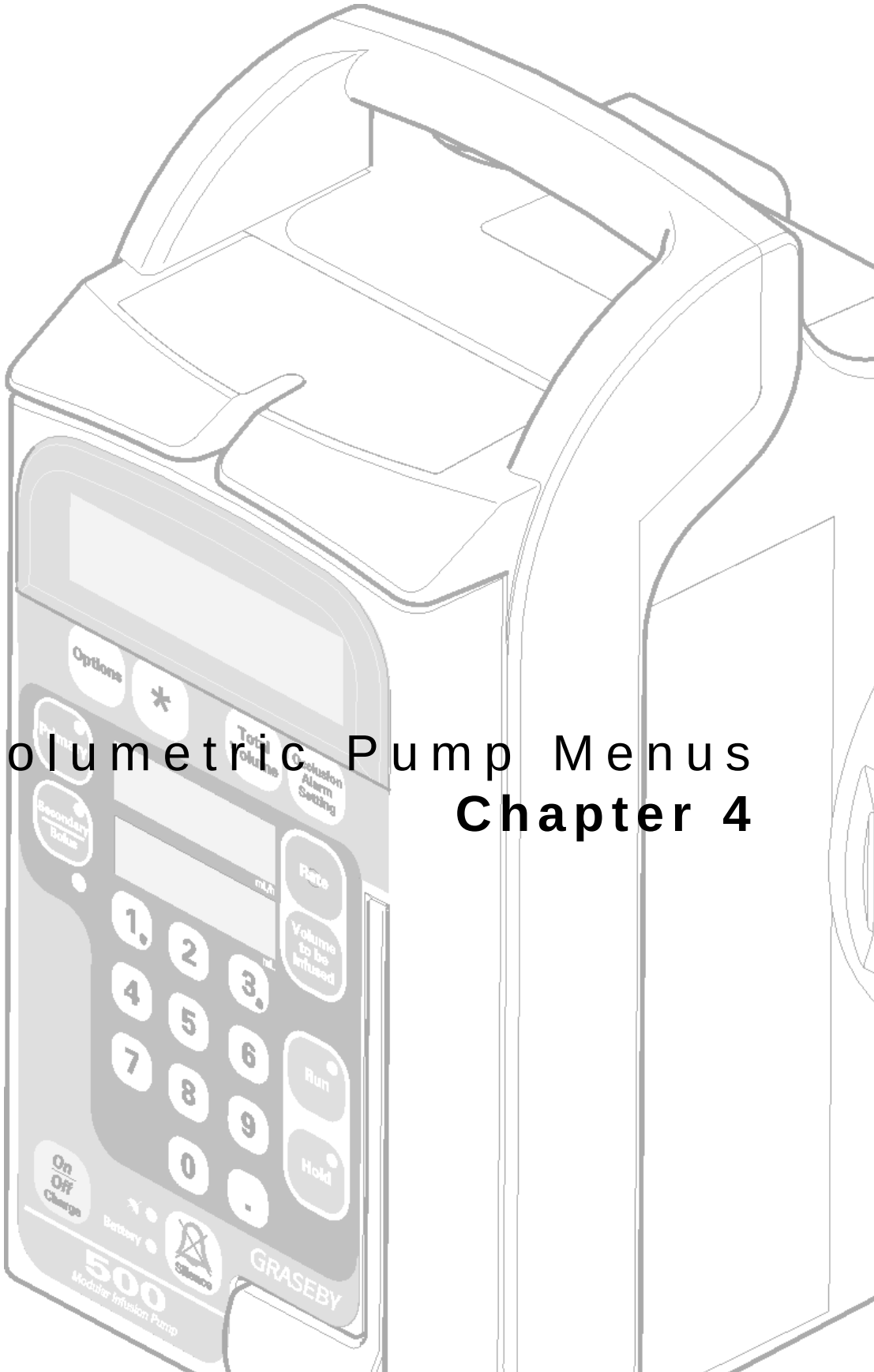
Audio alarm specifications

The table below shows the specifications of the audio alarms. See Biomedical Menu, page 4-26 for details on how to test these:

Name of alarm	Description	Frequency of chimes	
		High	Low
Insistent	high/high/low chime every 2.25 seconds	3,000 Hz	2,200 Hz
Non-insistent	high/low chime every 2.25 seconds	3,000 Hz	2,200 Hz
Back Up	high pitched every 1.5 seconds	3,000 Hz	
Continuous	high pitched without pause	3,000 Hz	

Volumetric Pump Menus

Chapter 4



Volumetric Pump Menus

Which version of software is in the pump?

This manual reflects the menus that are available in Version 0.71 software for the Volumetric pump. A pump has version 0.71 software (or later) if:

- The Secondary infusion key appears as:

- The Instruction Label on the right hand side of the pump lists more than eight options.
- The Biomedical Model Number and Software Version menu (see Biomedical Menu, page 4-11) shows V0.71, for example:

```
Model 3000 V0.71
DB:3.65A MM:1.10
```

This manual also covers the Version 0.53, Versions 0.63, 0.65, and 0.67 software that may be installed in a Volumetric pump.

Introduction to menus

The menus are decribed in the following sections. However, for detailed operating procedures refer to the *Instruction Manual* and *Technical User Manual*.

The number of menus (some of which have overlap of features) available on a pump varies depending on the software installed. The full set of menus is as follows:

Technician

This menu is only present on pumps with version 0.71 software and later. You use the Technician menu to enable the features of the pump that have been introduced with version 0.71 software, as well as enabling the features that existed in earlier versions.

Biomedical

Available in all software versions. In previous documentation it is called the “Biomedical Special Functions”. As well as enabling or disabling features, it displays data for fault finding and calibration.

Service Functions

Contains functions for servicing and setting the time in the pump.

Special Functions

Used to initialise the pump, for example after NV RAM or CPU board replacements, or any software upgrades. Details of how to use the Special Functions to initialise the pump vary with the software version and are explained in Chapter 7, *Troubleshooting* section.

About the Technician menu

This menu appears in version 0.71 software (or later). It allows you to define how the pump behaves by setting values or by disabling or enabling parameters.

Common parameters on Technician and Biomedical menus:
The common parameters on both the Technician and Biomedical menus are Rate Taper, Volume Over Time and Dose Rate Calculation.

Entering the Technician menu

To enter this menu, first switch off the pump if it is switched on.

Then press the ***Total Volume*** key while simultaneously pressing the ***On/Off*** key. When you take your fingers off the keys, the pump switches on and you are asked to enter the Technician menu ID.

Enter the numbers **0002**.

As you enter the digits, asterisks (*) are displayed for security protection. If you make a mistake, you must switch the pump off to enter the correct ID. When prompted:

Enter the password **2020**.

The password is always 2020, and cannot be changed.

Using the Technician menu

When you enter the Technician menu, the first parameter is the one to enable or disable the display of the **Pump Identifier**. Move down the list by pressing the ***Options*** key. Use the ***** key to toggle a parameter. Thus if you see a screen like the following:

```
* to enable
PUMP IDENTIFIER
```

then the feature is disabled and you must press the ***** key to enable it.

You cannot move back through the menu. If you make a mistake, then you can continue to move through the list by continuing to press the ***Options*** key and the first item appears again when you reach the end. You may find it faster to switch off and start again.

To move through the list quickly, and avoid going past the item you want, you may also find it faster to count the number of times you press the ***Options*** key. The table on the next page has been numbered to help you do this.

Leaving the Technician menu

To exit from the menu, switch off the pump.

Summary of Technician menu parameters

The numbers on the left of this table show the number of ***Options*** key presses to reach the parameter. The default settings are the factory settings.

	Configuration Parameter	Operation	Default
	Pump Identifier	Enable or Disable	Disabled
1	Drug List	Enable or Disable	Disabled
2	Primary rate limits	Enable or Disable	Disabled
3	Primary Max VTBI	Enable or Disable	Disabled
4	Secondary/bolus rate limits	Enable or Disable	Disabled
5	Sec / Bolus Max VTBI	Enable or Disable	Disabled
6	KVO rate entry	Enable or Disable	Disabled
7	Occlusion Default	High, Medium or Low	Medium
8	Secondary Stop	Enable or Disable	Disabled
9	Bolus	Enable or Disable	Disabled
10	Quick Rate	Enable or Disable	Enabled
11	Rate Taper	Enable or Disable	Enabled
12	Volume over Time	Enable or Disable	Enabled
13	Dose Rate Calculation (DRC)	Enable or Disable	Enabled
14	DRC Recovery	Enable or Disable	Disabled
15	Backlight	Enable or Disable	Enabled
16	Autolock Keypad	Enable or Disable	Disabled
17	GMT Timestamp	Enable or Disable	Enabled
18	Service Date	Review or Date Entry	00/00/00
19	Micrograms	Selection 1 (µg) or 2 (mcg)	2

Using Technician parameters

Most parameters enable or disable features that appear when the ***Options*** key is pressed. All only affect one feature, but for some you may need to think about making another setting at the same time. For example, if you enable Primary rate limits, you might also enable Primary Max VTBI.

Pump Identifier

If you enable this parameter, when you press the ***Options*** key to move to the next parameter you can edit the identifier text. When the pump leaves the factory, this identifier is set to the serial number of the pump. You can change the identifier character by character by using the up and down keys (1 and 3) to cycle through alphanumeric values. Press the ***** key to move to the next character. Press the ***Options*** key when you are finished.

Note: Another separate identifier appears on the Special Functions Menu. This also contains the pump serial number and will need to be reset to the serial number if the pump's PCB is changed. See item 5 on page 4-30.

Drug list

Enabling this parameter gives the user the ability to choose a Drug label from a preset list of drugs. If it is disabled, then the label is not displayed.

Minimum and maximum primary rate

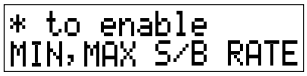
Enabling this parameter allows the user to define a range to limit the Primary rate.

Maximum primary VTBI

Enabling this parameter allows the user to set the maximum volume that can be infused for a Primary infusion.

Minimum and maximum secondary/bolus rate

Enabling this parameter allows the user to define a range to limit the Secondary rate or bolus rate.



Maximum secondary/bolus VTBI

Enabling this parameter allows the user to set the maximum volume that can be infused for a Secondary or Bolus infusion.

KVO rate entry

If this is enabled, then the user can set their own KVO rate. If it is disabled, the default KVO rate (as shown in the specifications) is used.

Occlusion default setting

Use this option to set the occlusion default setting that should be applied when the pump is switched on. Press * to change the default.

The user can press the ***Occlusion Alarm Setting*** key to change the occlusion level for a particular infusion regardless of this default parameter setting. However the default setting is reapplied when the pump is switched off and on again.

Secondary stop

With this parameter enabled, the pump stops when a Secondary infusion is completed. It sounds an insistent alarm and displays a message to say that the secondary infusion is complete.

If Secondary stop is disabled, when a secondary infusion is complete, the pump sounds a non-insistent alarm twice and then automatically restarts the infusion at the primary rate.

This parameter is independent of the setting of the Bolus parameter and only affects a Secondary infusion; at the end of a Bolus infusion the pump always reverts to the previously programmed Primary rate.

Bolus

When this parameter is enabled, the user is given a choice of whether a Secondary or a Bolus infusion is to be run when they press the ***Secondary/Bolus*** key. If Bolus is chosen, the volume infused is deducted from the Primary VTBI. If Secondary is chosen, the Secondary volume infused is kept as a separate total and does not affect the Primary VTBI.

If Bolus is disabled, the user is not given a choice when they press the ***Secondary/Bolus*** key: they can only make settings for a Secondary infusion.

Quick Rate Change

In software versions before 0.71, the Quick Rate Change parameter was always enabled, and could not be disabled. From version 0.71, the parameter may be enabled or disabled on the Technician Menu.

Enabling this feature allows users to use the ***Options*** key to put the pump into a mode in which they can change the rate quickly while the pump is running or on hold.

Rate Taper

Enabling this parameter allows the user to taper the infusion rate, either up or down, for the administration of Total Parenteral Nutrition (TPN), Total Parenteral Admixture (Three-in-One) or other applicable therapies.

Volume Over Time

Enabling this parameter allows the user to set up an infusion using the volume to be infused and the total time, with the pump automatically calculating the infusion rate. This can be done with either Primary or Secondary infusions.

Dose-Rate Calculation

Enabling this parameter allows the user to set the dosing rate, patient weight, the drug amount in the fluid bag and the volume in the container, from which the pump then calculates the infusion rate.

Note: If you enable Dose-Rate Calculation, the Micrograms unit should also be set (using the Micrograms parameter on this menu) according to your hospital's protocol.

DRC Recovery

Enabling this feature allows a Dose-Rate Calculation mode infusion to be accessed quickly when the pump is switched on.

Backlight

This parameter sets the default for how the backlight behaves when the pump is switched on. With the parameter disabled, the backlight will go off after a minute of keypad inactivity.

If the parameter is enabled, the user can use the ***Options*** key to control whether the Message Display Light is permanently on or behaves as described above when the option is disabled.

Autolock Keypad

With this parameter enabled, the keypad will automatically lock one minute after a key was pressed.

The user can unlock the keypad by pressing twice on the Keypad lock/unlock button on the back of the pump.

This is in addition to the manual keypad lock.

GMT Timestamp

Enabling this parameter displays the message 'GMT' to the right of the time display.

CAUTION: The backlight has a limited life and may, if used constantly, cause the light to dim. Eventually the message display may then need to be replaced. To preserve the life of the message display, you should only allow the Message Display Light to be turned on as described here if it is specifically required. Misuse of this feature could lead to both battery and LCD depletion.

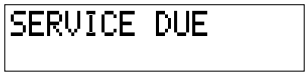
Service Date

This parameter is used to set the service due date that is displayed during power up when the pump is switched on. You can set or clear the service date when this screen is displayed with the date flashing on the Technician Menu:

Enter the new date in the format MM/DD/YY

To disable the Service Date feature, set the month, day and year to zeroes.

When the pump is switched on, if the date set is reached or exceeded, then an alarm is sounded and the following message is displayed:



to notify the user that the pump should be serviced.

Micrograms

Use this feature to determine the units to be displayed as µg or mcg for the Dose-Rate Calculation. If you are not enabling Dose rate calculation, you can ignore this item.

Note: Since the pump does not confirm the chosen unit display, test that the display is set correctly. Switch the pump on normally and press the ***Options*** key until the Message Display asks you to set the Dose-Rate calculation. Then press * to examine the next screen.

About the Biomedical menu

The Biomedical menu allows you to access technical information about the pump and carry out adjustments and tests. In previous documentation it has also been called the "Biomedical Special Functions"

System faults

If a fault occurs while the pump is infusing on a ward, an error code is recorded. An audio alarm sounds and the Message Display shows:

```
System check
Turn off then on
```

If the system error resulted from a temporary condition, turning the pump off then on clears the alarm and allows you to continue the infusion. However, if the above message persists, the pump must be removed from the ward for service and repair.

Error codes resulting from system errors can be viewed in the Message Display at a later time by entering the Biomedical menu and perusing the menu parameters described overleaf. The pump defaults to the screen displaying the error code.

Although the error codes are cleared when exiting the Biomedical menu, they are stored as a snapshot event.

Entering the Biomedical menu

To enter this menu, first switch off the pump if it is switched on.

Press the ***Options*** key while simultaneously pressing the ***On/Off*** key. When the keys are released, the pump switches on and you are asked to enter the Biomedical menu ID.

Enter the numbers **3031**.

As you enter the digits, asterisks (*) are displayed for security protection. If you make a mistake, you must switch the pump off to enter the correct ID. When prompted:

Enter the password **7867**.

The password is always 7867, and cannot be changed.

Leaving the Biomedical menu

Switch off the pump to exit the menu.

Using the Biomedical menu - if no error has occurred

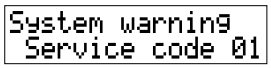
When you enter the Biomedical menu, the first screen you see depends on whether an error has occurred while the pump was running.

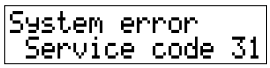
Navigate through the screens by pressing the ***Options*** key.

If no error has occurred, you go directly into Snapshot screen-a, see page 4-10. To view further menu screens, press the ***Options*** key.

Using the Biomedical menu - after a fault has occurred

If you enter the menu after a fault has occurred, system errors and warnings are displayed, for example:





When you switch off the pump to exit from the Biomedical menu, the warning/error code is cleared but stored as a Snapshot event, see page 4-11.

The table below shows the numbers that appear on the System Error and System Warning screens.

Code	Error/warning
01	Power Fail (Battery) Detected.
02	Motor Monitor Communication time-out error.
03	Motor Monitor RAM error.
09	Motor Monitor Watchdog error.
10	CPU1 ROM Checksum error.
11	Motor Monitor Checksum error.
12	CPU1 RAM failure.
13*	NV RAM checksum mismatch.
14	Main audio alarm Failure.
15	Motor fast error detected by Motor Monitor.
16	Motor slow error detected by Motor Monitor.
17	Motor disable test failure.
19	Air detect test failure.
20	No flow above pump circuit error.
21	Display board communications error.
22	Display digit error, 0-9.
23	Display LED error, 0-6.
24	Display Board ROM error.
25	Display Board RAM error.
28	Motor stall/interrupter.
30	Warm Boot.
31	Micro/Macro discrepancy error.
32	Pressure Plate Position Switch change during RUN.
33*	Corrupted Triple Redundant variable in NV RAM.
34	LCD Display Failure.
35	Undefined Interrupt occurred.
36	Display field overflow error.
37	Display field parameter error.
38	Nonvolatile RAM battery low.
39	Stack overflow.
40	Pressure Plate Position Switch =1 when door is open.
41	Pressure >1 psi when door is open.
42	Safety clip in place when door is open.

Items **31** and **33** are system errors; all others are system warnings.

* See *Faulty Component Identification* in the Troubleshooting section on page 7-17 for more details.

Summary of Biomedical menu parameters

The numbers in the left hand column of this table indicate the number of ***Options*** key presses to reach the parameter.

	Screen	Use	Notes/see page ...
0	026 0509 1145 19 3500 14000 01000	Two snapshot screens are available: **a** and b. Press * to toggle between the two screens.	See *About snapshot screens,* page 4-12.
1	14:18:50 GMT 10/23/00	Time and date display. GMT shown if enabled on the Technician menu.	See the Service Functions Menu, page 4-23
2	Hrs 19 Liters 9 Load 22	The display shows: • cumulative running hours, • cumulative volume, • number of loading cycles.	See page 4-23.
3	AC 18 Charge 73 Batt 2	Cumulative hours that the pump has been: • used on AC mains whilst switched on, • charging: plugged in but switched off, • used on batteries.	See page 4-23.
4	Pressure calib. 452 0 0 0	Allows you to run a calibration test.	See page 4-24.
5	Baud rate: 9600 ↓ ↑ to change	Shows the current rate setting of the serial port.	Rates of 300, 600, 1200, 2400 and are available. See page 4-25.
6	English ↓ ↑ to change	Displays the language installed in the pump.	Only one language is supplied in a pump.
7	Battery use 0.1 hr: 42	Displays the number of times a pump was used on battery for the number of hours indicated.	Use the scroll keys (1 and 3) to change the displayed number of hours. See page 4-25.
8	Model 3000 V0.71 DB:3.65A MM:1.10	Displays the model number and software revision.	See page 4-26.
9	Alarm Test Press 1,2 or 3	Use this screen to test the alarms by pressing 1, 2 and 3 on the keypad	See page 4-26.
10	Rate Taper	Enable or Disable.	See Technician menu.
11	Volume Over Time	Enable or Disable.	See Technician menu.
12	Dose Rate Calculation	Enable or Disable.	See Technician menu.

About Snapshot screens

Two Snapshot screens contain detailed information about the operation of the pump. Snapshot screen-a contains the first level of detail about an event, snapshot screen-b contains further details.

The information on the snapshot screens is encoded, in order to present a large amount of detail on the display area. This section describes the snapshot screens, and explains how to decode the information that they contain.

The pump stores 200 events (50 on a pre-version .63 pump). For each event, there is a snapshot screen-a and associated snapshot screen-b.

Using PC history software to interpret snapshot screens
A Graseby Medical History Download Software Kit is available. This enables you to view, log, store and print out the encoded information in an easy-to-read format, rather than carry out the manual decoding described here.

To display Snapshot Screen-a

If no error message has occurred on the pump immediately before you access the Biomedical Menu, then the first item displayed on the Biomedical Menu is Snapshot screen-a, showing event number 1. For details, see *Decoding Snapshot screen-a*, on page 4-12.

To display Snapshot Screen-b

When Snapshot screen-a is displayed, you can change the display to show the associated Snapshot screen-b:

Press *****.

To move back to Snapshot screen-a, press ***** again.

For details, see *Decoding Snapshot screen-b*, on page 4-15.

To display snapshots of next or previous events

To see snapshots of other events, use the **3▲** and **1▼** keys. For example:

On event 1, press **3▲** to see event 2. Press **1▼** to go to event 200 (or 50 on a pre-version 0.63 pump).

On event 200 (50) press **1▼** to go to event 199 (49) or press **3▲** to go to event 1.

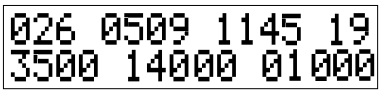
To show the next parameter

To move from the snapshot screens and show the next parameter (time and date display), press ***Options***. Press ***Options*** repeatedly to move through all the parameters. A description of the Biomedical Menu parameters starts on page 4-23.

Decoding Snapshot screen-a

Snapshot screen-a contains information in these fields, explained in the table below:

This is an example of values in fields in Snapshot screen-a, shown in the right hand column of the table below:



4

Top row of snapshot screen-a:

Field	Contains	Values/range	*Example shows*
###	Event number	1 is most recent event In range 1 - 200 or 1 - 50 for pre-version 0.63 pumps	*Event number 26*
MMDD	Month and day	Month 1 - 12, day 1-31	*May 9th*
HRMM	Hour and minute	Hour 0 - 23, minute 0 - 59	*11:45*
ZZ	System state code	0 - 99 - see table on page 4-13	*State code 19 air detector*

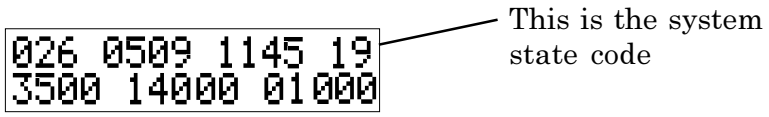
Bottom row of snapshot screen-a:

Field	Contains	Values/range	*Example shows*
RATE	Rate	0 - 999.0 mL/hr* on model 500/3000. 0 - 99.9 mL/hr * on micro 505/3100	*350.0 mL/hr*
VTOBI	Volume to be infused at the time of the snapshot	0 - 9999.0 mL* on model 500/3000. 0 - 999.9 mL* on micro 505/3100	*1400.0 mL*
VOLUM	Total volume infused this infusion	0 - 9999.0 mL* on model 500/3000 0 - 999.9 mL* on micro 505/3100	*100.0 mL*

* Implied decimal point, not displayed: rightmost digit is in 10ths mL

Snapshot screen-a - system state codes

This list shows the possible system/state codes shown on the top right hand line of a Snapshot screen-a:



Code	Meaning
00	No action, initialization value.
01	Power Fail (Battery) Detected.
02	Motor Monitor Communication time-out error.
03	Motor Monitor RAM error.
09	Motor Monitor Watchdog error.
10	CPU1 ROM Checksum error.
11	Motor Monitor Checksum error.
12	CPU1 RAM failure.
13*	NV RAM checksum mismatch.
14	Main audio alarm Failure.
15	Motor fast error detected by Motor Monitor.
16	Motor slow error detected by Motor Monitor.
17	Motor disable test failure.
19	Air detect test failure.
20	No flow above pump circuit error - return pump to SIMS Graseby or Service centre.
21	Display board communications error.
22	Display digit error, 0-9.
23	Display LED error, 0-6.
24	Display Board ROM error.
25	Display Board RAM error.
28	Motor stall/interrupter.
30	Warm Boot.
31	Micro/Macro discrepancy error.
32	Pressure Plate Position Switch change during RUN.
33*	Corrupted Triple Redundant variable in NV RAM.
34	LCD Display Failure.
35	Undefined Interrupt occurred.
36	Display field overflow error.
37	Display field parameter error.
38	Nonvolatile RAM battery low.
39	Stack overflow.
40	Pressure Plate Position Switch =1 when door is open.
41	Pressure >1 psi when door is open.
42	Safety clip in place when door is open.

list continues ...

***** see *Faulty Component Identification* in the Troubleshooting section on page 7-17

System state codes, continued

Code	Meaning
43	Service Due Alarm.
44	Secondary Stop Alarm
45	Preset Limits Exceeded Alarm.
62	Computer Interface Event.
63	Time Change Event.
64	On HOLD Alarm.
65	Stop pumping - Occlusion.
66	Stop pumping - Air.
67	Stop pumping - No flow above pump.
68	Stop pumping - Door Open.
69	Stop pumping - Loading problem, Pressure Plate.
70	Status of pump - Low Battery (11.0 < = voltage < 11.6).
71	Stop pumping - Dead Battery (voltage < 11.0 volts).
72	Stop pumping - Safety Clip.
73	Change rate to KVO.
74	Running rate change not completed.
75	On battery (loss of main power).
76	Start pumping using RUN key.
77	Stop pumping using HOLD key.
78	Secondary to primary switch.
79	Occlusion Alarm Setting change to low.
80	Occlusion Alarm Setting change to medium.
81	Occlusion Alarm Setting change to high.
82	Running rate change.
83	↓↑ rate change.
84	Taper to new rate.
85	Power down.
86	Pump on Battery.
87	Turn off AC.
88	Turn on AC.
89	Motor reverse stall.
90	Power change - battery to AC.
91	Dose change not completed.
92	Dose change not accepted.
93	Dose-Rate Calculation setup.
94	Dose field overflow.
95	Volume Over Time setup.
96	Dose-Rate Calculation setup not completed.
97	Door has been opened.
98	Pause pumping - excess pressure detected (software revision 0.64 and higher).
99	Resume pumping - pressure reduced (software revision 0.64 and higher).

Decoding Snapshot screen-b

On Snapshot screen-a, press ***** to display Snapshot screen-b.

This is an example of Snapshot screen-b:

```
026 072 004 029
139 008 194 131
```

Snapshot-b contains information in eight fields, explained in the table below. You would normally use the PC utility to interpret these fields.

```
### AAA BBB CCC
DDD EEE FFF GGG
```

Note: Fields are all decimal numbers in the range 0-255

The contents of GGG depend on the value of the System state code (ZZ) on Snapshot screen-a.

Field	Contains	Action and Detail Chart Ref.
###	Event number 1 is most recent event	
AAA	Pump's main modes	Convert decimal to binary then use *Chart A*
BBB	Pump's state modes	Convert decimal to binary then use *Chart B*
CCC	Pump's physical modes	Convert decimal to binary then use *Chart C*
DDD	Pump's sensor flags and status of the pump's occlusion alarm setting	Convert decimal to binary then use *Chart D* Occlusion alarm setting see bits 4 and 5 and use *Chart D-D*
EEE	Keyboard state input mode	Use *Chart E*
FFF	Battery voltage at time of snapshot, shown as the average of the last two analog-to-digital readings.	Use *Chart F*
GGG (all System state codes except for 33, 35 or 93)	Pumping pressure at time of snapshot: average pressure reading of the last two analog-to-digital readings.	Carry out calculation to compute the pumping pressure as described in *Chart G*

Field	Contains	Action
GGG state code **33**	*Identifier* for the Corrupted Triple Redundant variable in NV RAM	Use *Chart G - State Code 33*
GGG state code **35**	*Identifier* for the Undefined Interrupt	Use *Chart G - State Code 35*
GGG state code **93**	Dose-Rate Calculation dose mode and amount mode selected	Convert to hexadecimal then use *Chart G - State Code 93*

Converting Snapshot screen-b values from decimal to binary

This section does not explain the process of conversion, but shows the conversion of the fields on this sample Snapshot screen-b.

```
026 072 004 029
139 008 194 131
```

```
### AAA BBB CCC
DDD EEE FFF GGG
```

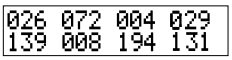
Fields A, B C and D on snapshot screen-b need to be converted into a binary format. If you do not have access to the History Download Software Kit for decoding snapshot screens (see page 4-11), you can use the examples in this section to remind yourself how to convert a decimal number to its binary equivalent.

The numbers on the screen above are explained in the table below:

- The top heading line shows how the bits are numbered, with bit zero on the right.
- The next heading line, in italics, shows the value that is assigned to each of the 8 bits.
- Each detail line shows the decimal value taken from the example screen in **bold**, and shows how each of the the bits are set to represent that decimal value (0 is off, 1 is on).
  For example, AAA has a decimal value of 72, so bit 6 (value 64) is set, and bit 3 (value 8) is set:

Bit number	7	6	5	4	3	2	1	0
Binary digit value	*128*	*64*	*32*	*16*	*8*	*4*	*2*	*1*
Field AAA **072**	0	1	0	0	1	0	0	0
Field BBB **004**	0	0	0	0	0	1	0	0
Field CCC **029**	0	0	0	1	1	1	0	1
Field DDD **139**	1	0	0	0	1	0	1	1

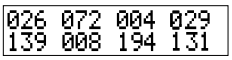
Chart A Pump Main Modes



Once you have converted the decimal value in field AAA into binary format, use this chart to find out the pump's state modes. The example of Snapshot-b shows field AAA's value as 072 (decimal), which converts into 01001000.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 =	Not used	Unit not in dose-rate calc	Unit not in quick rate change	Unit not in dead battery condition	Unit not in low battery condition	Unit not in KVO	Unit is in primary	Unit not running
1=	Not used	Unit is in dose-rate calc.	Unit is in quick rate change	Unit is in dead battery condition	Unit is in low battery condition	Unit is in KVO	Unit is in secondary	Unit is running

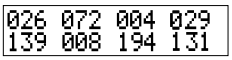
Chart B Pump State Modes



This chart shows the state modes that can be decoded from field BBB on Snapshot-b when the value is converted to binary. The example of Snapshot-b shows a value of 004 (decimal) which converts into 00000100.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 =	Primary/ secondary rate/volume not decimal since total volume last cleared	Secondary VTBI does not have decimal place	Secondary rate does not have decimal place	Primary VTBI does not have decimal place	Primary rate does not have decimal place	Standard message not in message display	Pump not in rate taper end early	Pump not in rate taper
1=	Primary/ Secondary rate/volume was decimal since total volume last cleared	Secondary VTBI has decimal place	Secondary rate has decimal place	Primary VTBI has decimal place	Primary rate has decimal place	Standard message is in message display	Pump is in rate taper end early	Pump is in rate taper

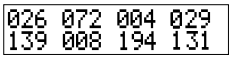
Chart C Pump Physical Modes



Convert the value in CCC to binary then use this table to decode the bits. In the example screen, the decimal value is 029, or binary 00011101.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 =	Not used	Run not pending	Not used	Cassette not in position	Not used	Safety clip not in place	Door not open	Pump not turned on
1 =	Not used	Run pending	Not used	Cassette in position	Not used	Safety clip in place	Door open	Pump turned on

Chart D Pump sensor flags and occlusion alarm setting



Once you have converted the decimal value into binary format, use this chart to determine the pump's sensor flags and status of the pump's occlusion alarm setting. In the example Snapshot screen-b, field DDD shows a value of 139 decimal. This converts to 10001011 in binary format.

	Bit 7	Bit 6	Bit 5 and Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 =	Micro jumper	Not Used	Occlusion alarm status - see Chart DD below	Auxilliary power off	CTS not active	Keypad not locked	Pump on AC
1 =	No Micro jumper			Auxilliary power off	CTS active	Keypad locked	Pump on battery

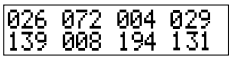
4

Chart DD - Occlusion alarm status

Use this table to determine the occlusion alarm status from bits 5 and 4 of the binary representation of field DDD.

Bit 5	Bit 4	Occlusion alarm setting
0	0	Undefined
0	1	Low
1	0	Medium
1	1	High

Chart E - Keypad State Input Mode

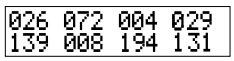


Use this chart to determine the keypad state input mode. Do not convert to binary. Take the value from field EEE on Snapshot screen-b.

Value	Mode
0	Keypad default mode.
1	Occlusion Alarm Setting.
2	Options.
3	Quick Rate Change.
4	Total Volume.
5	Taper End Early.
6	Taper setup.
7	Keypad Locked.
8	Rate input.
9	Volume to be Infused input.
10	Taper Run.
11	Volume Over Time setup.
12	Dose-Rate Calculation setup.
13	Dose Run.
14	Dose-Rate rate titrate.
15	Dose-Rate dose titrate.

The example snapshot screen-b shows field EEE with a value of decimal 008, so the keypad state input mode is 'Rate input'.

Chart F - Battery Voltage



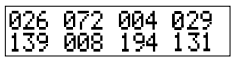
Use this chart to convert the average value of the last two analog-to-digital readings into the battery voltage at time of snapshot. Take the value from field FFF on Snapshotscreen-b.

Analog-to-Digital Value	Voltage
186	11.1
188	11.2
190	11.3
191	11.4
193	11.5
195	11.6
197	11.7
199	11.8
200	11.9
202	12.0
204	12.1
205	12.2

Analog-to-digital values that fall between those listed in the table may be interpolated to determine the voltage.

For example, the example snapshot screen-b shows the value as decimal 194, so the voltage value is 11.55.

Chart G - Pumping pressure



Use this section to interpret field GGG on snapshot screen-b for all system state codes except 33, 35 or 93 which are described later in this chapter. This example shows field GGG with a value of 131.

These instructions explain how to compute the pumping pressure of the pump at the time of the snapshot.

The pressure sensor has a zero offset Analog-to-Digital value of 0 to 3. In addition to that, every increment of 21 represents 1 psi.

Use the following steps to compute the pumping pressure contained in field GGG on Snapshot-b:

1. Take the decimal value in GGG and subtract 5.

2. Divide the result by 21 to give the pressure in psi.

These steps can be represented by the formula:

(GGG-5) / 21 = *n* psi

As an example of how the formula works:

If the value of GGG is 131: (131-5) / 21 = 6 psi

Chart G - State Code 33 - Corrupted Triple Redundant variable in NV RAM

If the system state code on screen-a is 33, find the identifier of the corrupted variable by checking the value of GGG on screen-b:

GGG	Variable Identifier
0	Micro/Macro flag
1	Rate calibration factor
2	Pressure search limit
3	Back off pressure
4	Language select
5	Baud rate
6	Pump serial number
7	Pump enabled for Volume Over Time
8	Pump enabled for Dose-Rate Calculation
9	Rate Taper enable flag
10	Volume Over Time enable flag
11	Dose-Rate Calculation enable flag
12	Alternate search pressure
13	Alternate search rate
14	Search occlusion pressure
15	Back off range low
16	Back off range high
17	Serial key flags
18	Back off method
19	Long search half step limit

Chart G - State Code 35 - Undefined interrupt

If the system state code on screen-a is 35, find the cause of the undefined interrupt by checking the value of GGG on screen-b:

GGG	Interrupt Identifier
0	Reset
1	Clock monitor
2	Cop watchdog
3	Bad opcode
4	Software interrupt (SWI)
5	Non-maskable interrupt (XIRQ)
6	Hardware interrupt (IRQ)
7	Real time interrupt
8	Timer input capture 1
9	Timer input capture 2
10	Timer input capture 3
11	Timer output compare 1
12	Timer output compare 2
13	Timer output compare 3
14	Timer output compare 4
15	Timer output compare 5
16	Timer overflow
17	Pulse accumulator overflow
18	Pulse accumulator input edge
19	Serial Peripheral Interface
20	Serial Communications Interface

Chart G - State Code 93

If the system state code (ZZ) on Snapshot screen-a is 93, then GGG on snapshot screen-b contains a decimal representation of a hexadecimal value. This hex value encodes the *amount mode* and *dosing mode* selected by the operator during a Dose-Rate Calculation program setup.

If the system state code is 93 use the instrucitons in this section to convert the value to hexadecimal and then interpret the result using the table below.

To convert the GGG value:

1. Take the decimal number, and divide it by 16.

2. The initial quotient is 'digit 1' and the remainder is 'digit 0'.

As an example, if the value of GGG was 052:

052 / 16 = 3 (digit 1), with a remainder of 4 (digit 0).

To interpret the result

Look up the resulting values for digit 1 and digit 0 in the table below to find out the dosing mode and amount mode:

Digit 1 - Amount mode		Digit 0 - Dosing mode	
0	MG/bag	0	mcg/kg/min
1	Gm/bag	1	mcg/min
2	mcg/bag	2	MG/min
3	units/bag	3	MG/hr
		4	units/hr
		5	MG/kg/hr
		6	mch/kg/hr
		7	MG/kg/min
		8	units/kg/hr

In the example above:

Digit 1 with a value of 3 indicates an Amount mode of units/bag

Digit 2 with a value of 4 indicates a Dosing mode of units/hr.

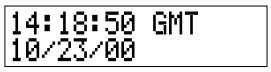
Using Biomedical Parameters

This section explains how to use the Biomedical Menu parameters, summarised on page 4-10. To find out about the snapshot screens and how to decode them, see page 4-11.

Press the ***Options*** key to navigate from one parameter to the next.

You cannot move backwards; to redisplay a parameter, press the Options key repeatedly to move through all the parameters until you see the one you require.

Time and date display



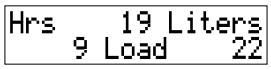
The first line displays the time in the format hh:mm:ss.

GMT is only displayed if it has been enabled on the Technician menu, see page 4-6.

The second line displays the date in the format mm/dd/yy.

To change the date or time, use the Service Functions menu described on page 4-29.

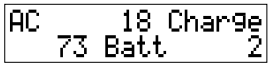
Pump history display



This parameter shows a summary of the statistics for pump usage. It shows:

- **Hrs**: cumulative hours that the pump motor has been running. The number of hours can range from 0 to 99999. This example shows that the pump has been running for 19 hours.
- **Liters**: cumulative volume infused, in liters. The volume infused ranges from 0 to 99,999 litres. The volume shown in the example above is 9 litres.
- **Load**: number of loading cycles - the number of times that the door has been opened. The value is in the range 0 to 99999. The example above shows 22 load cycles.

Charge History



This parameter shows a summary of the pump's charging history. It shows:

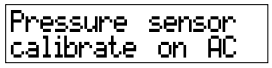
- **AC**: total number of hours that the pump has been turned on whilst plugged into the AC mains supply. The hours can range from 0 to 99999. This example shows 18 hours.
- **Charge**: AC charge time. This is the accumulation of time the pump is plugged in and turned off. Range from 0 to 99999. For software versions 0.67 this accumulation is updated provided the pump is turned on before being unplugged. For software versions 0.71 the pump will log the time it is plugged into the AC and not switched on as 'Charge Time', regardless of whether the pump was switched 'ON' before AC was removed. The example shows AC charge time of 73 hours.
- **Batt**: total number of hours the pump has been turned on and powered by battery, i.e. not plugged in. The example shows 2.

The total number of hours that the pump has been switched on (cumulative hours of operation) is the sum of **AC** and **Batt** hours, in this example, 20 hours.

Pressure display parameter (on battery power)

You can only calibrate the pressure transducer on the front door assembly sensor of the pump when the pump is connected to the AC mains supply.

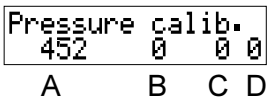
If the pump is operating on battery power, the pressure calibration mode parameter is not shown. Instead, you see the screen:



If you connect the pump to the AC mains supply while this screen is shown, the pressure calibration mode screen will appear, as shown over the page.

Pressure display - calibration mode

If the pump is operating on AC mains supply, the pressure transducer on the front door assembly sensor may be calibrated, so you see this parameter:



The bottom line of this screen shows four fields, marked on the above example as A, B, C and D. They are described in the table below:

Field	Range	Comment
A	0 to 1919 unref or *	Represents motor position. It shows 'unref' if the motor cam position is unreferenced. It shows * in the first position if a motor stall was detected.
B	0 to 1919	Represents the position immediately before the last motor "home" position realignment. If there is no significant motor slippage, expected display values are between 0 and 40 or 1880 and 1919.
C	0 to 255	Raw analog-to-digital pressure reading from the display board. This value is read and the Message Display value updated at least twice per second. This permits occlusion alarm calibration to a known pressure by adjusting two potentiometers, see *Occlusion alarm adjustment* on page 8-15..
D	1, 0 or -	Represents the pressure plate position switch, where: 1 = cassette-in-position 0 = no cassette present - = communication error when switch is read.

Pressure transducer calibration screen

The default rate is 25 mL/h. To adjust the rate:

- Press ***Rate*** and enter a rate with the number keys. The run light flashes whenever a rate can be entered using number keys.

To accept the entered rate:

- Press ***Run***. The rate appears in the rate display.

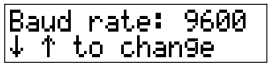
To toggle the motor direction:

- Press ***Primary***. If the motor is running backwards, the pumping indicator shows a minus sign. If the motor is running (forward or backward) the run light is continuously lit.

To stop the motor.

- Press ***Hold***. When the motor stops the hold light is lit.

Baud rate

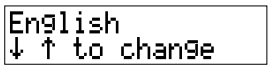


This screen displays the current baud rate selection for the computer port: 300, 600, 1200, 2400, 4800, or 9600. The default baud rate is 9600 baud.

Press ***1*** (↓) or ***3*** (↑) to display the next or previous baud rate. If you press ***1*** (↓) when 300 baud is shown, the display changes to 9600. If you press ***3*** (↑) when 9600 baud is displayed, the display changes to 300.

Press ***Options*** or ***On/Off*** to accept the last baud rate shown.

Language



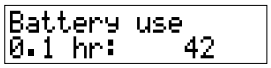
This screen displays the language currently in the pump's software. The above example shows English, but the pump may show any one of the following:

English French German Italian Spanish

Dutch Swedish Japanese Portuguese

Only one language is supplied in any one pump. Contact Graseby Medical to determine language availability. Pressing 1 (↓) or 3 (↑) will not change the language selection.

Battery use



The pump records information about the number of times it is used on battery. It records the information against the period of time for which it was used.

For example, the screen above shows 'Battery use 0 - 1 hr: 42', indicating that the pump has been used 42 times for one hour or less.

Use ***1*** (↓) or ***3*** (↑) to see how many times the pump has been used on battery for the other periods of time:

0-1 hours	4-5 hours
1-2 hours	5-6 hours
2-3 hours	6-7 hours
3-4 hours	7+ hours

The maximum number of hours that can be shown is 99999.

Model number and software version

The model number and software version parameter contains information in these fields, explained in the table below:

```
Model XXXX VY.YY
DB:Z.ZZz MM:G.GG
```

This is an example of the screen:

```
Model 3000 V0.71
DB:3.65A MM:1.10
```

The values in this example are shown in the right hand column of the table below.

Field	Contains	Example
XXXXX	Model number: **3000** or **3100** (In the U.K. only, the Volumetric Infusion Pumps are called 500 and 505.)	*3000*
VY.YY	Software version resident in the ROM of the main processor	*0.71*
DB:Z.ZZz	Software version resident in the Display Board microprocessor	*3.65A*
MM:G.GG	Software version resident in the Motor Monitor microprocessor	*1.10*

The lower case **z** in the above screen is always present on 'Dose-Rate' pumps. It signifies the language selected.
It is only present when a language other than English was selected on 'non Dose-Rate' pumps.

Audio alarm test

```
Alarm Test
Press 1,2 or 3
```

This screen allows you to verify proper operation of the audio alarms by pressing a key to sound each type of alarm:

- Press 1 to initiate a ***non-insistent*** alarm
- Press 2 to initiate an ***insistent*** alarm
- Press 3 to initiate a ***backup*** audio alarm
- Press any other key to stop the alarm.

The hardware which produces the *Back Up* audio alarm is the same as that used by the *Continuous* alarm.

Audio alarm specifications

The table below shows the specifications of the audio alarms:

Type of alarm	Repetitions	Frequency of chimes High	Low
Insistent	high/high/low chime every 2.25 seconds.	3,000Hz	2,200Hz
Non-insistent	high/low chime every 2.25 seconds.	3,000Hz	2,200Hz
Back Up	high pitched every 1.5 second.	3,000 Hz	
Continuous	high pitched without pause.	3,000 Hz	

Enabling special programming functions

In software versions before version 0.71, the Rate Taper, Volume over Time and Dose-Rate Calculation pump programming modes could only be enabled or disabled on the Biomedical Menu of Dose-Rate pumps.

From version 0.71, these parameters appear on the Technician Menu described on page 4-2, as well as on the Biomedical Menu.

It is recommended that you should place an external label on a pump to indicate which functions have been enabled.

Enable/disable rate taper

Enabling this parameter allows the user to taper the infusion rate, either up or down, for the administration of Total Parenteral Nutrition (TPN), Total Parenteral Admixture (Three-in-One) or other applicable therapies.

Use the ***** key to toggle this parameter. Thus if you see a screen like the following:

```
Press * to
disable Taper
```

then the rate taper is enabled and you must press the ***** key to disable it.

If you press *****, the screen changes to:

```
Press * to
Enable Taper
```

Press the ***** key again to re-enable the Rate Taper mode.

Enable/disable volume over time

Enabling this parameter allows the user to set up an infusion using the volume to be infused and the total time, with the pump automatically calculating the infusion rate. This can be done with either Primary or Secondary infusions.

Use the ***** key to toggle this parameter, as described for *Enable/ Disable Rate Taper*, on page 4-27.

Enable/disable dose-rate calculation

Enabling this parameter allows the user to set the dosing rate, patient weight, the drug amount in the fluid bag and the volume in the container, from which the pump then calculates the infusion rate.

If you enable Dose-Rate Calculation, the Micrograms unit should also be set (using the Micrograms parameter on the Technician Menu, see page 4-5) according to your protocol.

Use the ***** key to toggle this parameter, as described for *Enable/ Disable Rate Taper*, on page 4-27.

About the Service Functions menu

The Service Functions menu allows you to set the date and time on the pump and to test some pump functions.

Entering the Service Functions menu

To enter this menu, first switch off the pump if it is switched on.

Then, press the ***Occlusion Alarm Setting*** key while simultaneously pressing the ***On/Off*** key. When you take your fingers off the keys, the pump switches on and you are asked to enter the Service Function menu ID.

Enter the numbers **7557**.

As you enter the digits asterisks (*) are displayed for security protection. If you make a mistake, you must switch the pump off to enter the correct ID. When prompted:

Enter the password **3796**.

The password is always 3796 and cannot be changed.

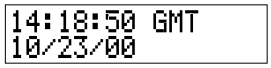
Using the Service Functions menu

When setting up the pump, the main use of this menu is to set the date and time.

Setting the date

To set the date and time:

1. Enter the service functions menu as described above.
2. Press ***Options*** to display the screen:



3. Enter the time and date as a string of numbers in the format HH:MM:SS MM/DD/YY.
4. Press ***Options*** again to display the next parameter. The parameters on the menu are described on the next page.

Note: If Version 0.71 (or later) software is installed, 'GMT' may be hidden, by disabling the GMT timestamp parameter on the Technician Menu, see page 4-6.

Leaving the Service Functions menu

Switch off the pump to exit the menu.

Service Functions menu parameters

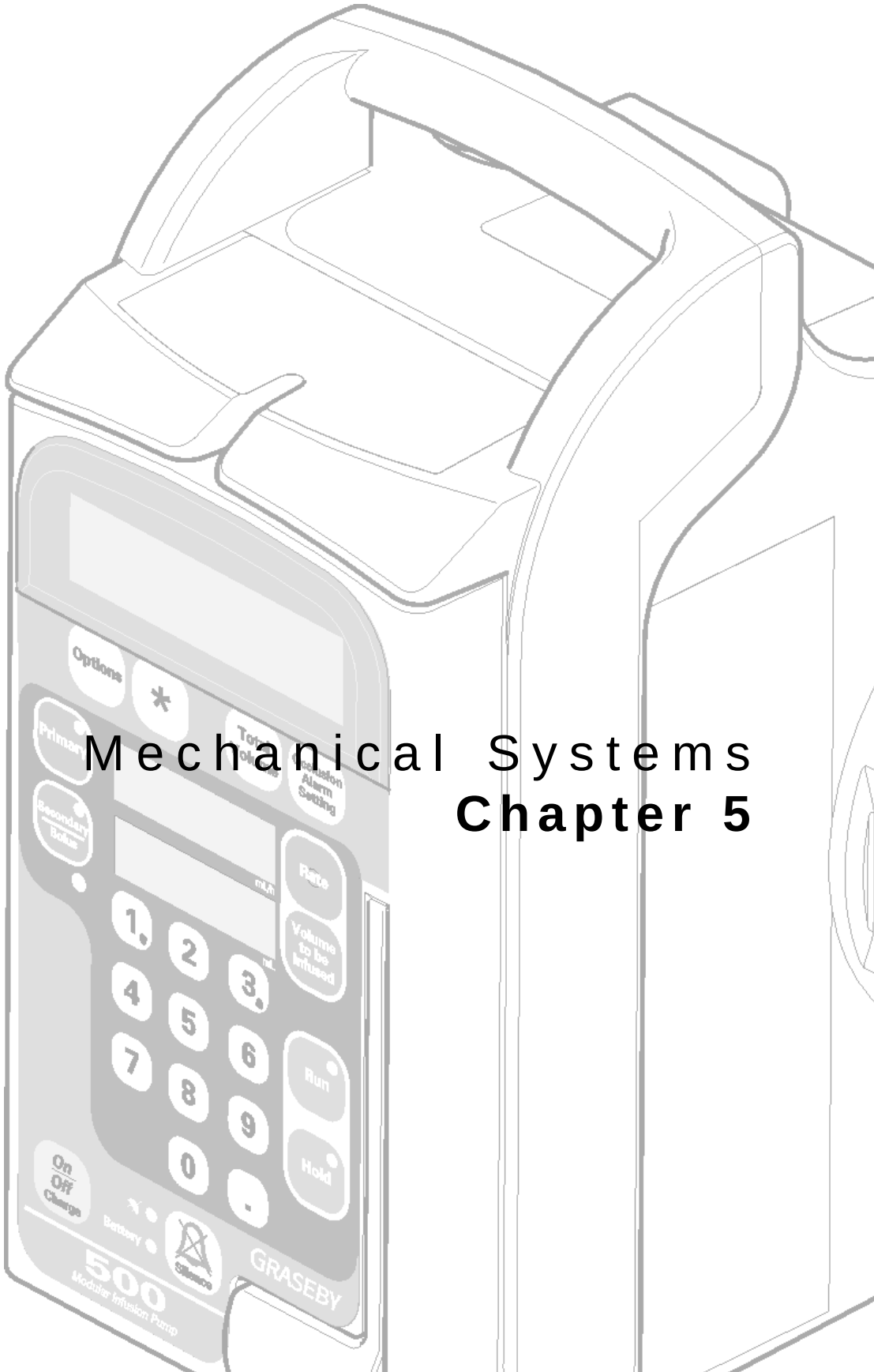
The numbers on the left of this table show the number of ***Options*** key presses to reach the parameter.

This list is for software versions 0.67 and 0.71 only. For older software versions including 0.53 and 0.63 there are other screens displayed where the displayed parameter should not be adjusted.

	Screen	Use	Notes
	Steps: 0 A/D: 0 0 0 0	Information for Graseby Medical Service Department use.	
1	14:18:50 GMT 10/23/00	Use this to set the time and date in the format HH:MM:SS and MM/DD/YY.	In order to set the date, first you must enter the time. In Version 0.71 software, GMT can be disabled on the Technician menu
2	0 of event 1 press ↓ ↑	The top line shows the number of times that each event code has occurred. Use the scroll keys to select an event code to be displayed.	The event is the event in Snapshot *screen-a* of the Biomedical Menu. Event Codes 43, 44 and 45 will not be logged in this Event History Summary .
3	Sensors: DR0 CL0 CS0 PL0 ON0 JP0	Status of six sensors as shown on the table below.	
4	Keys pressed:	Press a key to check that it is functioning correctly. The key pressed shows on the second line of the screen.	Pressing the ***Options*** key once will show that you have pressed that key Pressing it again will take you to the next menu option
5	ID: 300006212	Shows the serial number of the pump as on the back of the case.	If you need to enter the serial number on a pump that has been upgraded or had the main board changed, press * to enter the number.
6	Press * to clear pump history	Take care with this option, since the action is irreversible. You are given a chance to change your mind.	You can download history by using the Volumetric Infusion Pump History Download Kit.

Status of sensors

Sensor	Description	Value = 0	Value = 1
DR	Door	Closed	Open
CL	Clip	Out	In
CS	Cassette	None	Fitted
PL	Keypad Lock	Unlocked	Locked
ON	On/Off key	Released	Pressed
JP	Jumper JP10 on CPU board	3000/500	3100/505



Mechanical Systems
Chapter 5

Mechanical Systems

Linkage system

The pumps employ a linkage system to move the cam housing/ pumping mechanism between the load position and the operate position (see Fig. 5.1). The *load* position is used to load and unload the fluid filled cassette.

The *operate* position brings the pistons and valves of the pumping mechanism in contact with the cassette, and is monitored by the microprocessor as it reads a signal from the cam housing switch positioned on the cam housing.

The pumping mechanism is spring loaded to keep it in the load position whenever the door is opened. When the door is closed the linkage mechanism is actuated by the handle/arm assembly and the pumping mechanism is drawn forward into the operate position. Once in the operate (door closed) position, the latch lever secures the pumping mechanism in place.

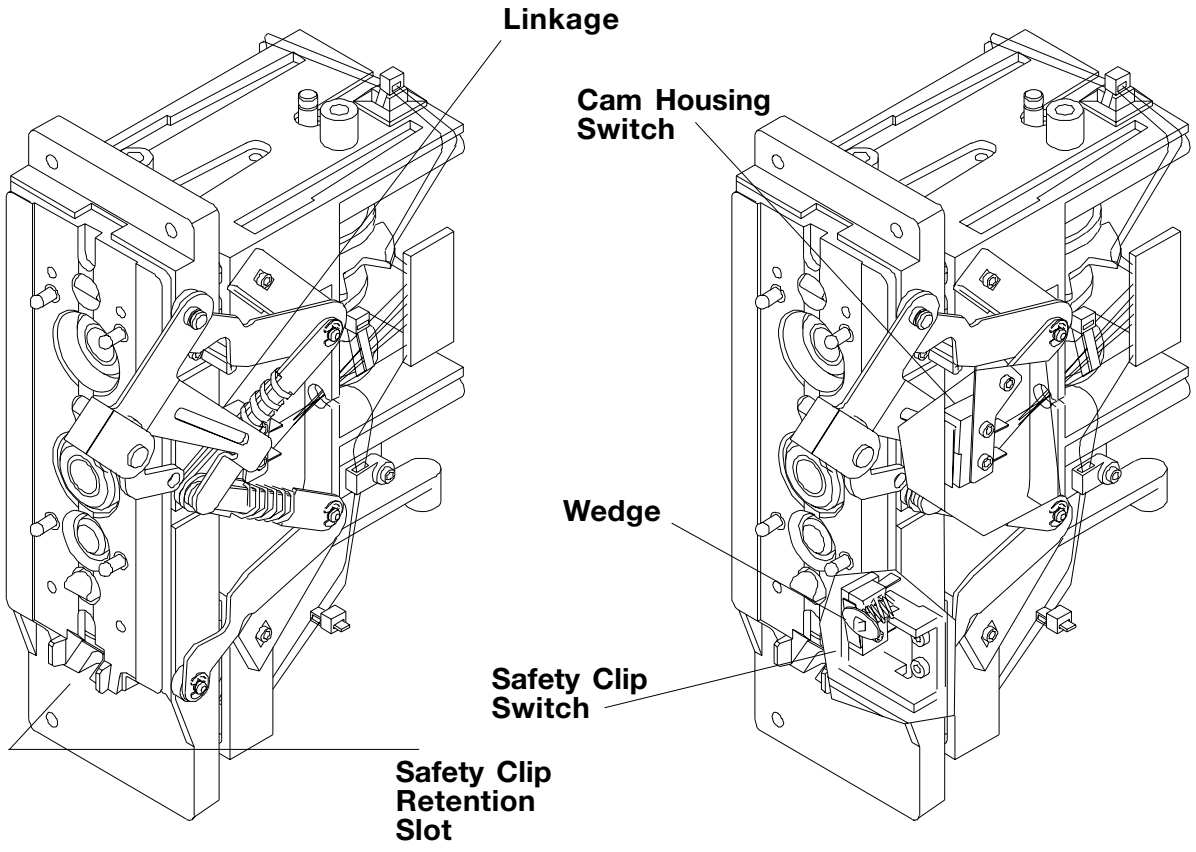


Figure 5.1 Linkage system and safety clip switch

Cassette housing and door

The cassette housing and door of the pump (see Fig. 5.2) are designed for one step loading. Opening the door turns the pump on and causes the microprocessor to set the pistons and valves in the ready position. After a cassette and Safety Clip are loaded the door can be closed by swinging the door shut and pushing the door latch in.

The cassette housing and door secure the cassette in the proper position for loading and operation. The cassette position is established by placing the cassette (flat side out) over the 4 loading pins built into the cassette housing. The cassette housing is mounted to the front cover of the pump and is stationary.

The door is also mounted to the front cover using 2 hinge brackets. When the door is closed, it provides a flat stable surface for valve sealing and manipulation of the cassette chambers by the pistons.

In the door is a spring loaded pressure plate. When a fluid filled cassette is placed on the cassette housing and the door is closed, there is a considerable amount of pressure developed in the cassette. The pressure plate is spring loaded to accommodate this pressure build up. The pump relieves the pressure by reversing motor direction and channelling the solution back up to the fluid container.

Once pressure has been reduced, the pressure plate springs push the plate toward the cassette housing. A position sensor (mounted on the plate) is activated when the pressure plate reaches a specified distance from the cassette housing. The microprocessor reads this sensor and determines if the pressure has been adequately relieved. If loading was successful, the pump can be run; if not, an ***insistent*** alarm sounds and an alarm message is displayed.

The pressure plate also houses a pressure transducer used to monitor occlusion alarm pressure. The transducer is positioned over the middle cassette chamber, and provides continuous pressure monitoring while pumping. Amplifier gain and zero offset are adjusted using trimpots R439 and R448, which can be accessed at the bottom of the door assembly. If pressure exceeds the selected Occlusion Alarm Setting, an ***insistent*** alarm is generated.

In addition to the pressure plate and sensors described above, the door assembly also houses the display board, LCD, keypad, CPU3 memory chip, and photosensor.

Safety clip retention slot

The Safety Clip, located on the administration set, is inserted into the Safety Clip retention slot on the cassette housing (see Fig. 5.1). The Safety Clip occludes the IV tubing whenever the door latch is pulled out. When the door latch is pushed in, the arms of the Safety Clip are spread apart by the wedge inside the safety clip slot, thus allowing an infusion.

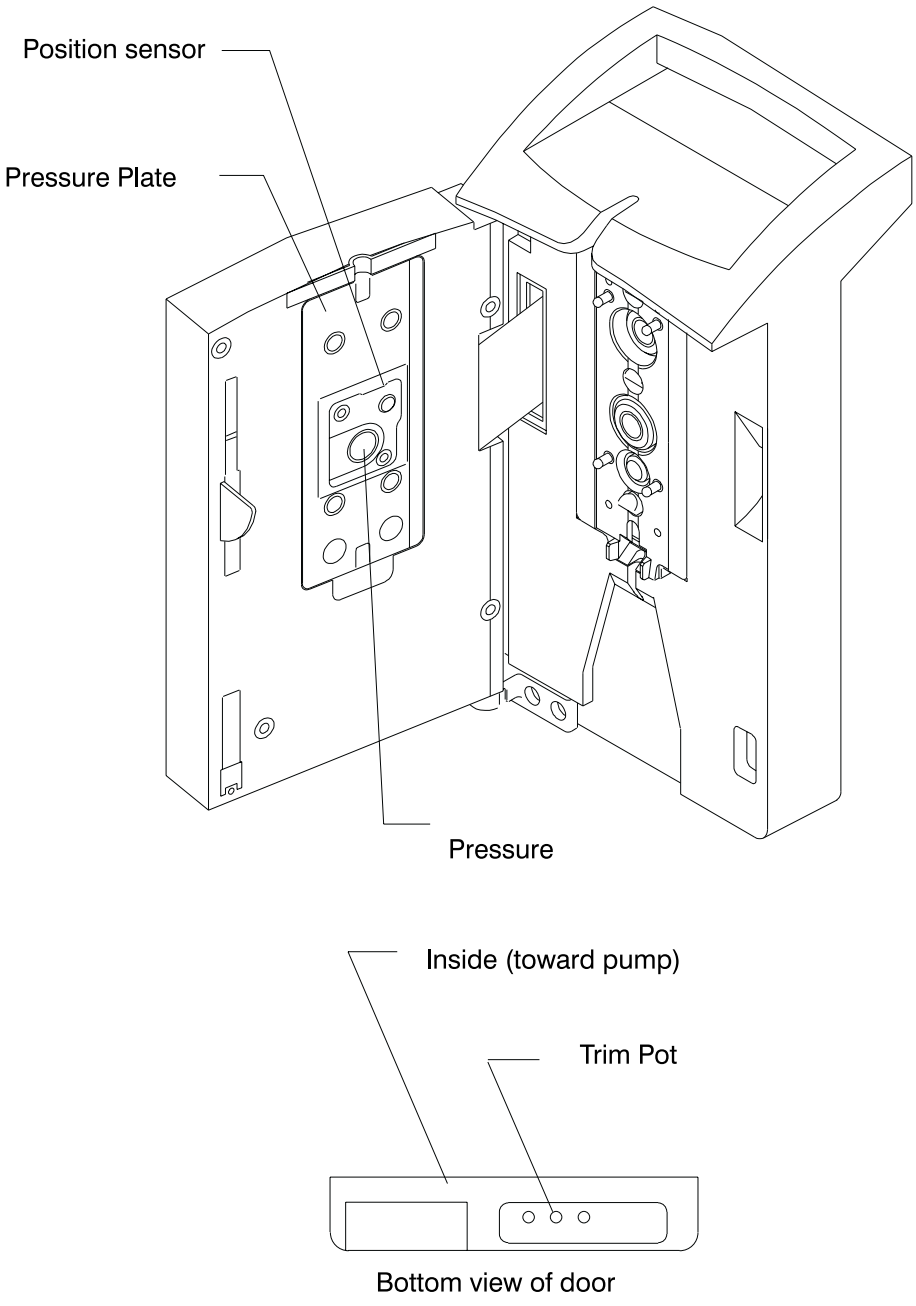


Figure 5.2 Cassette housing and door

Cam housing switch and safety clip switch

The cam housing switch and safety clip switch are two sub-miniature switches that monitor the cassette loading process (see Fig. 5.1). They alert the microprocessor to the door open and safety clip alarm conditions. If either switch is not activated, the pump will not operate.

The cam housing switch (which is normally closed) is mounted to the upper right side of the cam housing. It is activated by the cassette housing as the pumping mechanism is drawn forward during the loading process. The cam housing switch is opened as the door is closed.

The safety clip switch (which is normally open) is mounted to the bottom front of the cam housing. It is activated by the safety clip on the administration set, when the clip is inserted into the retention slot and the door is closed.

5

Cam housing

The moulded cam housing is coupled to the front housing of the pumps via the linkage system (see Fig. 5.3). The cam housing acts as the main supporting structure for the electro-mechanical pumping mechanism. The stepping motor mounts onto the lower portion of the cam housing with its shaft pointing upward. Coupled to the motor shaft is the vertical cam shaft which turns in the bushing inserts. The encoder wheel, valve and piston cams of the pumping mechanism are moulded onto the cam shaft.

The electro-mechanical components, the overpressure piston; valve; two pumping pistons and valves, all operate within the cam housing. Mounted to the cam housing are the cam housing switch, safety clip switch, flex wedge assembly and the I/O circuit board.

Stepping motor

A four phase, synchronous stepping motor (see Fig. 5.3, item 3) is used in the pumping mechanism. The step angle is 7.5 degrees and the gearbox reduction ratio is 20:1.

The motor is operated by circuitry on the I/O board according to a control program in micro-processor memory. To provide smooth rotation, the motor is half-stepped for rates 0.1 mL/h through 499 mL/h. At rates of 500 mL/h and above the motor is whole stepped. The CPU1 sends commands to U106 on the I/O board, which sends on/off signals for each of the four motor coils. These signals, in conjunction with a step pulse, cause motor motion.

Due to the 20:1 gear reduction and half stepping, 1,920 pulses yield one full revolution for rates of 499 mL/h and less. Each cam shaft revolution and the resulting cycle of the pumping mechanism delivers approximately 1.7 mL of fluid. Delivery of fluid to the patient is smooth since each mL is delivered in approximately 1,130 increments. The 3100/505 pump is half stepped at all rates.

At rates of 500 mL/h and above, due to the gear ratio of 20:1 and whole stepping the motor, each mL of fluid is delivered in approximately 565 increments.

Cams, pistons and valves of the pumping mechanism

The motor's mounting shaft is connected to a vertically mounted cam shaft (see Fig. 5.3, item 13) by the motor coupler (item 4), interface coupler (item 5), and hub coupler (item 6). Four cams (items 8, 9, 11 and 12) and an encoder wheel (item 10) are moulded onto the cam shaft. The cams actuate four horizontal shafts, which in turn drive two valves and two pistons which produce the pumping action.

Pumping cycle description (Figs 5.3, 5.4 and 5.5)

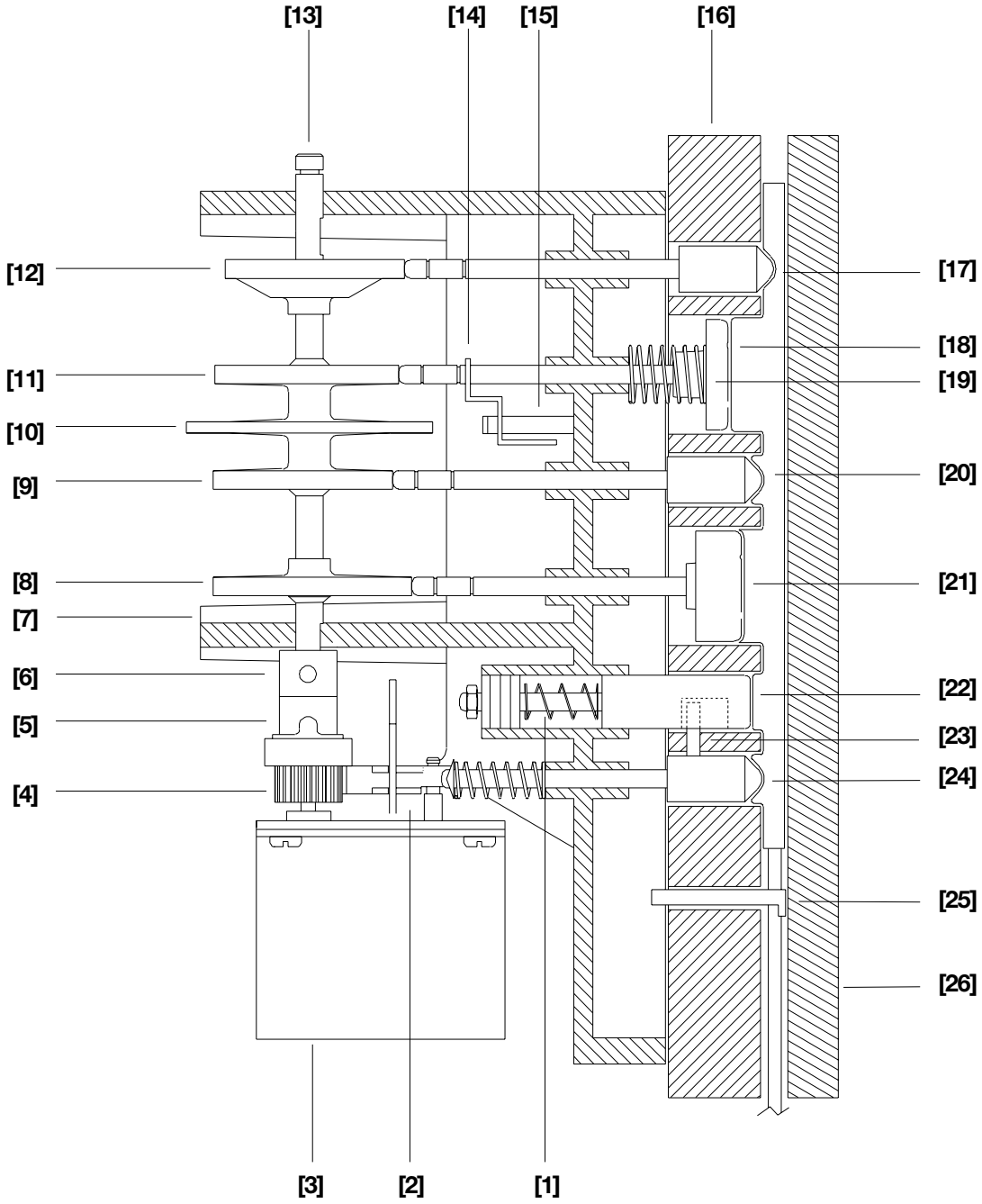
1. The cam shaft revolution causes the upper valve (item 17) to open, allowing flow to the upper cassette chamber and upper piston (see item 18). The lower valve (item 20) closes, thus stopping flow between the upper and lower cassette chamber (lower piston).The smaller, lowest chamber on the cassette is in contact with the overpressure piston (item 22) and is the point where internal pumping pressure is continuously regulated.

2. The upper piston (see item 18) begins to draw back as fluid flows from the upper tubing into the upper cassette chamber. At the same time, the lower piston (item 21) begins to slowly push forward, forcing the fluid in the lower cassette chamber into the lower tubing, towards the patient.

3. Once the upper piston (item 18) has moved fully back and the lower piston (item 21) fully forward, the upper valve (item 17) closes and the lower valve (item 20) opens. The upper piston (item 18) then begins to push forward to force the fluid in the upper cassette chamber downward into the lower cassette chamber, where the lower piston (item 21) is beginning to draw back to receive the fluid. The upper piston moves forward delivering fluid more rapidly when the lower piston draws back, causing a continuous stream of fluid to be forced out of the lower tubing to the patient.

4. The lower valve (item 20) closes and the upper valve (item 17) opens as the upper piston (item 18) reaches its furthest forward point of travel and the lower piston (item 21) its furthest back travel. The cycle then repeats.

The result of the above cam, piston and valve action is a smooth flow of fluid through the lower tubing to the patient. Each full revolution of the cam shaft delivers approximately 1.7 mL of fluid as governed by the precise and unvarying travel of the pistons. The rate of fluid delivered is determined by the rate at which the motor is stepped.



[1] Spring
[2] Swing Arm
[3] Stepping Motor
[4] Motor Coupler
[5] Interface Coupler
[6] Hub Coupler
[7] Cam Housing
[8] Piston Cam
[9] Valve Cam
[10] Encoder Wheel
[11] Piston Cam
[12] Valve Cam
[13] Cam Shaft
[14] Wire Contact
[15] Spring Contact
[16] Cassette Housing
[17] Upper Valve
[18] Upper Piston
[19] Piston Spring
[20] Lower Valve
[21] Lower Piston
[22] Overpressure Piston
[23] Connect Shaft
[24] Overpressure Valve
[25] Safety Clip Retention Slot
[26] Pressure Plate/Door

Figure 5.3 Pumping mechanism

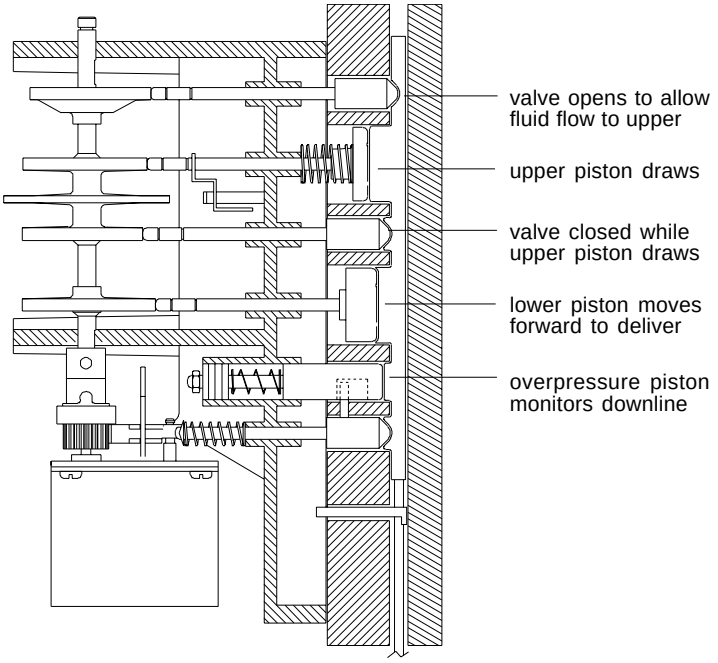

valve opens to allow fluid flow to upper
upper piston draws
valve closed while upper piston draws
lower piston moves forward to deliver
overpressure piston monitors downline

Figure 5.4 Pumping cycle

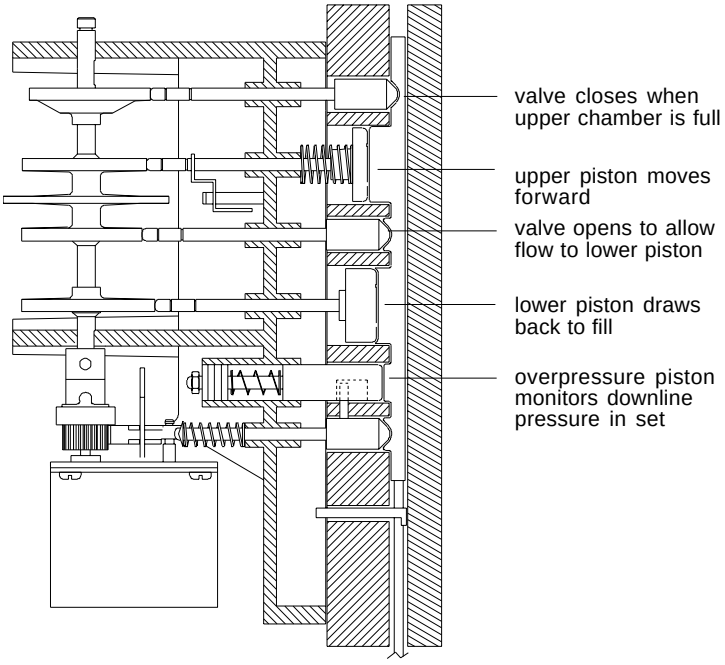

valve closes when upper chamber is full
upper piston moves forward
valve opens to allow flow to lower piston
lower piston draws back to fill
overpressure piston monitors downline pressure in set

Figure 5.5 Pumping cycle

Encoder wheel and interrupter

The encoder wheel (item 10) is mounted to the cam shaft (item 13) which is turned by the stepping motor to drive the pumping mechanism (see Fig. 5.3 and 5.6). The interrupter assembly is mounted to the back of the cam housing (via the I/O board) so its emitter and detector arms straddle the encoder wheel. A light beam, produced by the emitter, is alternately allowed to reach the detector and then blocked by the teeth of the encoder wheel as it turns.

Data from the interrupter detector is read through the parallel to serial interface chip U108 on the I/O board. The microprocessor monitors the interrupter output in relation to the motor drive pulses delivered.

If the micro-processor senses an incorrect response from the pumping mechanism, a system warning is generated, sounding an alarm and displaying the message:

```
System check
Turn off then on
```

In this manner, the encoder wheel and interrupter alert the micro-processor to binding, hesitation or stalling of the motor and pumping mechanism.

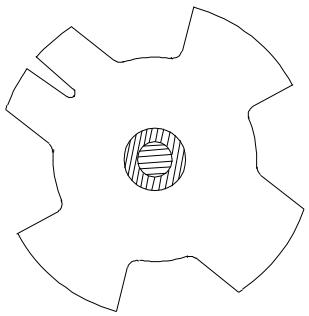


Figure 5.6 Encoder wheel

Empty bag contacts

The empty bag contacts (see Fig. 5.3) consist of a rigid wire contact and a spring contact and are used in detecting the "**No flow above pump**" alarms. The wire contact (item 14) is connected to ground potential. The spring contact (item 15) is mounted to the cam housing. The position of the spring contact is adjusted by a set screw located on the right hand side of the cam housing. The empty bag contacts must touch briefly, once per revolution of the pumping mechanism. Contact occurs only when the upper piston is in the major depression area of the metering cam.

The upper piston (item 18) is loaded to the ***out*** position by a light spring (item 19). Pressure caused by the solution container and proper head-height overcomes this spring tension and causes the upper piston shaft to maintain contact with the drive (metering) cam throughout the pumping cycle. An empty fluid container or inadequate head-height allows the piston to lose contact with the metering cam. The wire contact fails to touch the spring contact and an alarm results.

Sensors

Pressure sensor

The occlusion pressure and alarm conditions are monitored by a solid state pressure transducer which interfaces directly with the middle chamber of the fluid filled cassette. The transducer is a differential pressure transducer which, when activated by a constant current source provides an output voltage proportional to the applied pressure. The output of the transducer is amplified by a two-stage instrumentation amplifier which provides output analog voltages in the range of 0 to 5V. Output voltages from the amplifier are read by the display board microprocessor via an 8-bit analog to digital converter.

When an "Occlusion below pump" alarm occurs, the motor briefly backs off before entering hold. The over pressure condition is thus reduced while you locate and correct the cause of back pressure. A swing arm closes the over pressure valve to prevent reverse fluid flow while the motor is backing off.

Pressure plate position sensor

The pressure plate position sensor (housed in the pressure plate in the door) provides information to the display board microprocessor regarding the position of the cassette housing and pressure plate. The sensor itself is a microswitch that activates when the pressure plate comes within a specified distance from the cassette housing.

Photo sensor

The pump systems include a photo sensor device used to monitor ambient light levels and adjust the LED display intensities accordingly. The photo sensor is a photoconductive cell which has a cell resistance that varies inversely with illuminance. The cell resistance varies from approximately 10K ohms to approximately 1M ohms. The cell is designed into one leg of a resistor divider network and the voltage generated across the cell is read by the display board micro-processor via the 8-bit analog to digital converter.

Over pressure valve and swing arm

The over pressure valve (item 24, Fig. 5.3) is located directly below the over pressure piston (item 22). The swing arm (item 2) is attached to the cam housing at the rear of the over pressure valve shaft. The toothed section of the swing arm engages the motor coupler and is held in ready position by a torsion spring. The swing arm rides on the toothed surface of the motor coupler while the pump is running. When the motor backs off, the swing arm catches on the motor coupler and forces the over pressure valve outward, occluding the fluid pathway. In this way, reverse fluid flow is prevented whenever the pumping mechanism backs off.

In the event an administration set is loaded improperly, excess pressure can build up in the cassette. If this happens the pump alarms and remains on hold. During this period, the excess pressure within the cassette pushes the pressure plate away from the cassette housing. In this situation the pressure spring, mounted on the over pressure valve shaft, forces the valve outward, keeping it in contact with the pressure plate and preventing free flow.

Back pressure regulation

Proper performance of the pump depends on constant conformity of the fluid filled cassette to the cassette housing and pistons during the pumping cycle. A small amount of pressure within the cassette is therefore needed to maintain proper cassette form. The over pressure valve (item 24, Fig. 5.3) and the over pressure piston (item 22) function together to create a resistance to the fluid flow for the purpose of providing this needed pressure. Internal cassette pressure must be great enough to maintain cassette form, yet kept below the threshold of the Low Occlusion Alarm Setting.

The over pressure valve restricts fluid flow during operation which results in internal cassette pressure. The position of the over pressure valve and resulting pressure is influenced by the over pressure piston.

The over pressure piston and valve are coupled by a vertical connect shaft (item 23). The over pressure piston is slotted where it joins the connect shaft. This slot allows semi-independent movement between the valve and piston.

During operation, the rear edge of the piston slot makes contact with the connect shaft. The piston assembly contains a spring (item 1) which is precisely adjusted for the proper force. It is this spring force (which is applied to the over pressure valve via the shaft) that governs internal cassette pressure.

Should a small temporary pressure increase occur within the cassette, the over pressure piston is pushed to the rear of the pump. The vertical shaft disengages from the piston. The internal pressure also pushes the over pressure valve to the rear, causing less flow restriction. The resulting decrease in internal cassette pressure allows the piston to move forward and engage the connect shaft, thus reasserting spring tension to the valve. This restores the desired level of internal cassette pressure.

The preloaded over pressure valve opens as forward rotation of the pumping mechanism begins. The preload force is overcome when pressure reaches approximately 1 psi. However, the break open pressure varies and is sometimes higher than 1 psi.

To avoid nuisance occlusion alarms in the Low Occlusion Alarm Setting during start up, the pressure threshold is temporarily set to 5 to 6 psi. After a brief transition period to allow break open of the over pressure valve, the pressure threshold reverts to 2 psi. The Low setting should only be used with lower flow rates.

Pole clamp and IV pole

The pole clamp is designed to function with pole diameters of 1.2 cm and 3.8 cm (0.5 and 1.5 inches). It supports the weight of three infusion pumps. Turn the knob clockwise to attach the pump to the pole and counter clockwise to remove the pump.

Modular connection system

In use, Graseby Medical recommend that the pump should be connected to a suitably balanced IV pole using the pole clamp as illustrated in the diagram on the opposite page.

To provide maximum stability when using the modular connection system, ideally the IV pole should have 6 wheels and low centre of gravity. The base diameter should be 56 cm (22 inches).

Attaching a single pump to an IV pole

To attach the pump to a suitably balanced IV pole:

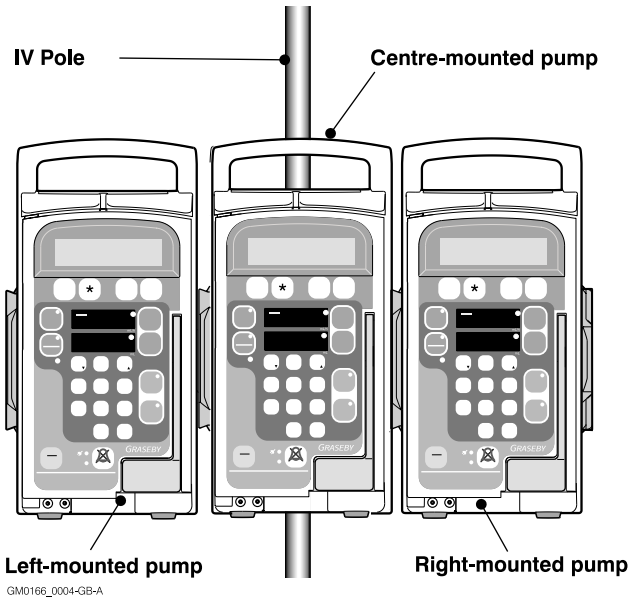
1. Loosen the screw on the pole clamp.
2. Hold the pump by the handle and slip the arms of the pole clamp onto the pole.
3. Tighten the screw on the pole clamp to firmly attach the pump to the pole.

Attaching more than one pump to an IV pole (Revised case design shown here)

When multiple infusion lines are required, you can connect up to three pumps to a single pole using the hooks and rails that make up the modular connection system.

As all pumps have connectors on both sides, you can use any one as the centre, left, or right pump.

This diagram shows how three pumps may be connected together using the Volumetric's modular connection system:



Inspecting the modular connections

Before connecting the pumps, you must check that the modular connection parts are all in good condition:

1. Carefully inspect the modular connection system for damage, including cracks, chips, loose or bent parts.
2. Press the disconnect buttons several times to make certain that the buttons move in and out freely.

WARNING: Do not use the pump if you detect any cracks, chips and loose or bent parts, or if the buttons do not move in and out freely when they are pressed. Failure to do so could cause inadvertent disconnection of the pumps.

How to connect pumps together

Once you have inspected the modular connection system as described in the previous section, connect the pumps as follows:

1. Clamp the first pump to the IV pole. This is now the "centre" pump.

Note: As you tighten the screw on the pole clamp, the actuator arm adjusts the modular connection hook and disconnect button. Once the pump is securely attached to the pole, the hook is in the correct position to allow connection of further pumps.

2. Take the second pump, grasping it by the handle and hold it so that the modular connector rails are directly above or below the connector rails of the centre pump.

3. Engage the edges of the modular connector rails and slide the second pump up or down until it is connected to the centre pump. When the connection is secure, you hear a distinct click. If you do not hear a distinct click when connecting the pumps then the modular connection system has not engaged properly.

4. Before releasing the handle of the second pump, double-check that the connection is secure by moving the pump up and down and exerting pressure on the top of the pump.

To attach a third pump to the other side of the first pump, repeat steps 2, 3 and 4.

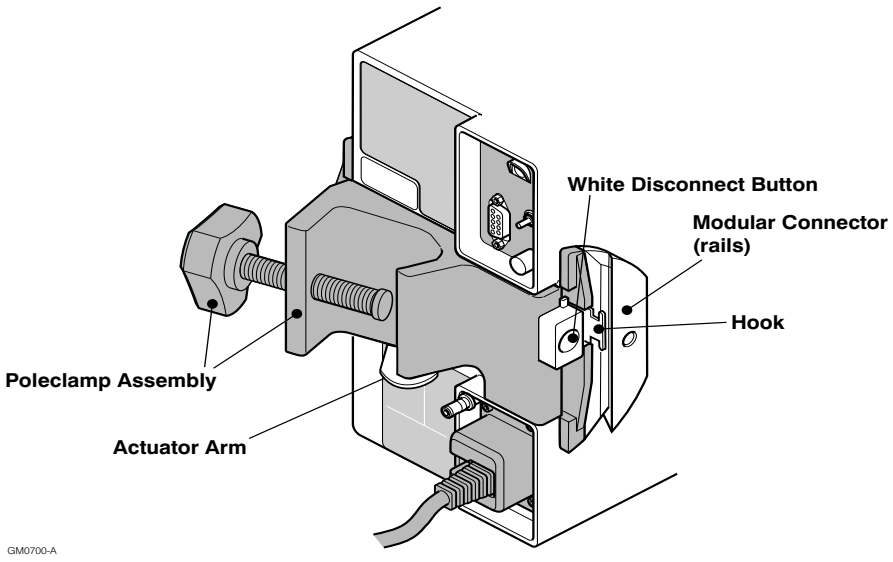


Figure 5.8 Pole clamp and modular connecting system

WARNING: Do not use the pump if you detect any cracks, chips and loose or bent parts, or if the buttons do not move in and out freely when they are pressed. Failure to do so could cause inadvertent disconnection of the pumps.

Moving an IV pole with pumps connected

If you need to move the IV pole once the pumps are attached, always ensure that you grasp the IV pole with one hand and steady the pumps with the other hand if necessary.

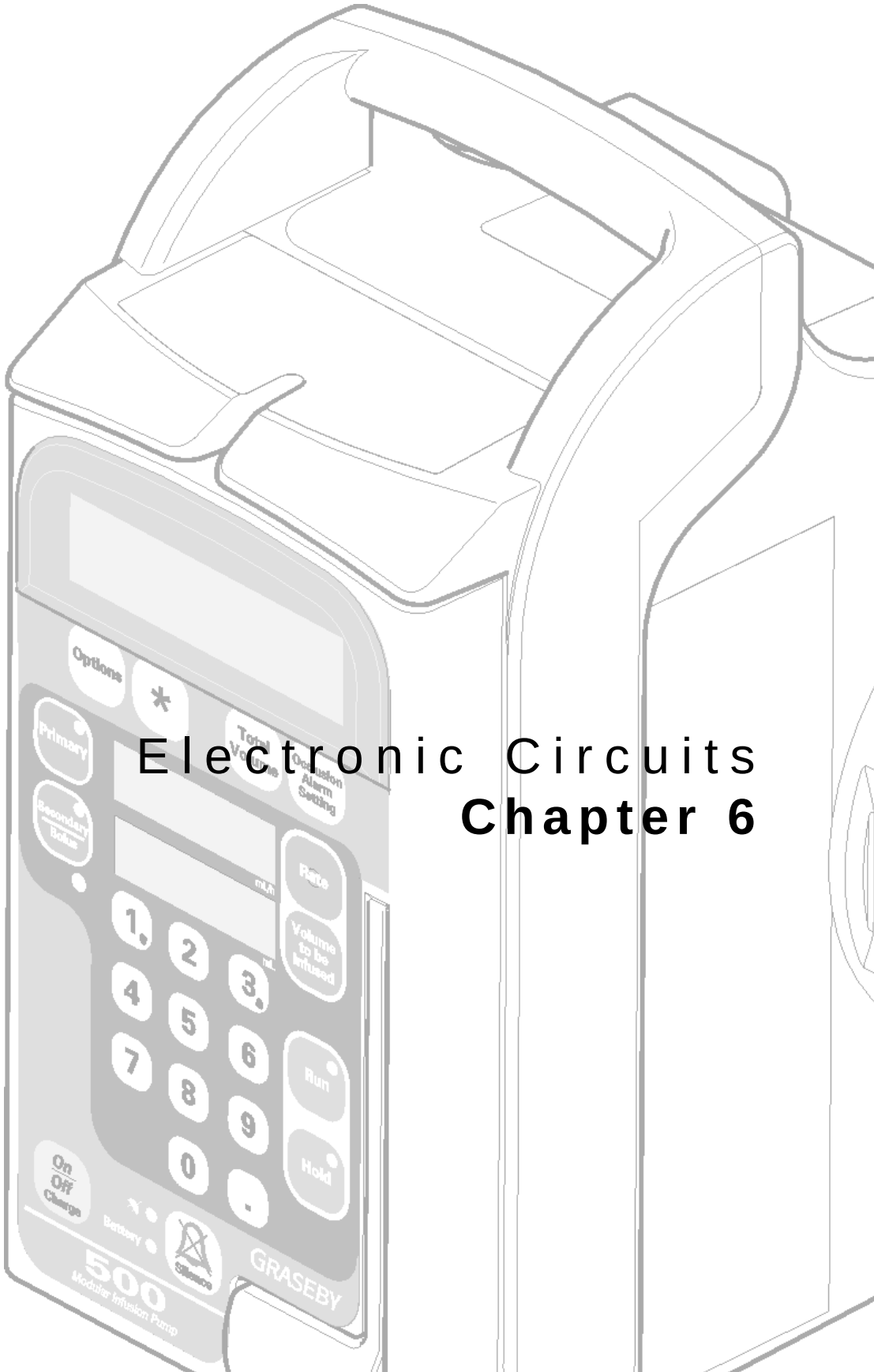
Disconnecting modular connected pumps

You must always disconnect modular connected pumps one by one before removing the centre mounted pump from the IV pole.

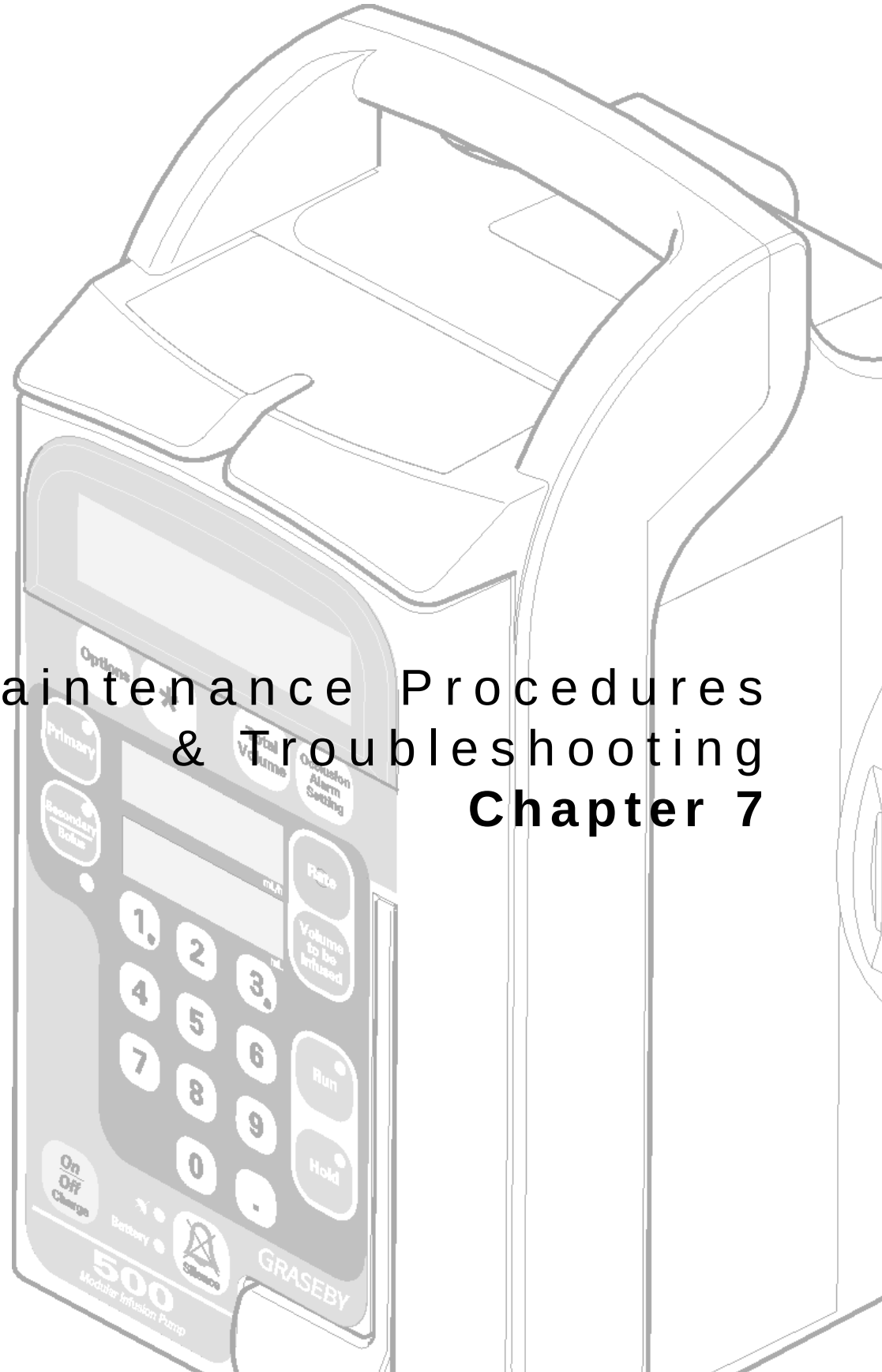
Disconnect the left and right hand pumps from the centre mounted pump as follows:

1. Grasp handle of pump to be removed.
2. Lift the pump slightly.
3. Press the disconnect button and slide the pump up or down to disconnect from the centre pump.
4. Place the pump in a location where it will not be damaged.

WARNING: Do not push or pull on the pumps, or the IV pole may tip over or the pumps fall to the floor. Do not try to remove modular connected pumps from the IV pole whilst they are joined together. Either of these could cause the administration set to separate from the fluid container thus spilling the medication, or the pumps themselves could be damaged.



Electronic Circuits
Chapter 6



Maintenance Procedures & Troubleshooting

Chapter 7

Maintenance Procedures

Introduction

The information and procedures presented in this chapter are intended to enable the user to achieve satisfactory performance over the life of the pump. However, this maintenance information should not be considered inclusive. The purchaser is encouraged to contact the Graseby Service Centre when necessary. The contact details are listed in Chapter 1.

Note: Infusion pumps are precision medical instruments. When returning a pump to the Service Centre for repair it should be packaged for shipment in a manner which provides protection against physical shock or other shipping damage. It is strongly recommended that the pump is shipped back in the original shipping carton to prevent damage.

Recommended test equipment

The following equipment is recommended for performing the functional and accuracy checks described on page 7-8:

- An air regulator which ranges from approximately 2 psi to 12 psi (Bellofram 10-B or equivalent). This compressed air source is connected to the lower end of an installed administration set in order to verify the accuracy of occlusion alarm thresholds and valve sealing integrity.
- An in-line digital pressure meter with a minimum range of 0 to 15 psi (BioTek Universal Pressure Meter DPM-2).
- A 50 mL burette graduated in 0.1 mL increments is used to verify the ±2% accuracy. The burette must be traceable to the National Institute of Standards and Technology (NIST).
- A digital stopwatch (Microtimer), with a minimum 2 decimal places (100ths of second) is used to verify the rate accuracy.

Recommended troubleshooting equipment

The following equipment is recommended for troubleshooting possible infusion pump malfunctions:

- A multimeter (Beckman 3010 or equivalent) is used to verify AC and DC voltages, battery charging current, resistance, continuity, etc.
- An oscilloscope (Tektronix 2213 or equivalent) is useful for electronic signal tracing and viewing various waveforms.
- Regulated DC power supply (B & K 1601 or equivalent) is used to power the pump when the AC power cord and battery are both disconnected. The power supply must be capable of providing at least 2 Amperes at 12 Volts. The output must be adjustable to 0.01 Volt increments. A 2K Ohm trimpot placed in a series with the power supply's voltage adjusting component yields fine voltage adjustment.

The power supply is used in place of the pump's battery when testing battery voltage trip points. The DC voltage is varied to simulate decreasing battery voltage.

- A ground tester is used to test ground resistance.
- A digital Safety Analyser (BioTech Model 170 or equivalent) is used to measure leakage currents.

Service tool kit

To assist in the servicing of a pump Graseby supply a Service tool kit. This tool kit can be ordered from the Graseby Customer Care department. The part number of the Service tool kit is:

78-8061-4214-3

The tool kit consists of the following items:

- Torx bit handle.
- T7 torx bit.
- T7W torx bit.
- T10 torx bit.
- T15 torx bit.
- Keypad tool (label peeler).
- C-ring tool.
- Tool pouch.
- Allen key (0.89 A/F).
- 2 sizes of feeler gauge,

  Note: the 2 sizes of feeler gauge may also be purchased separately using the following part numbers:

Diameter	*Length*	*Part number*
0.31 mm 0.012 inch	65 mm 2.5 inch	78-8098-2259-2
0.38 mm 0.015 inch	65 mm 2.5 inch	78-8098-2262-6

Periodic cleaning

The pump may require periodic cleaning. This section lists the recommended cleaning agents, and describes the recommended procedure for cleaning the pump.

Recommended cleaning agents

Use any of the cleaning agents listed here as directed in *Cleaning Procedure and precautions*, on the next page.

Soap

It is recommended that only soap and water solutions are used to clean the outer surface of the pump. These solutions have little disinfecting and sterilizing properties.

Quaternary ammonia salt-based solutions

Quaternary ammonia salt-based solutions are typically liquid concentrates mixed with water, and are used for routine wipe-down to clean and disinfect. These solutions may be effectively used for routine wipe-down of the pumps with no adverse effects.

Alcohol solutions

It is recommended that only 70% concentrations of isopropyl or ethyl alcohol in water be used in cleaning and disinfecting the pumps. However, solutions of **methyl** alcohol should **never** be used in cleaning the pumps.

Bleach solutions

Bleach solutions diluted to 1 part bleach to 10 parts water (approximately 0.5% solution) may be effectively used for routine wipe-down of the pumps with no adverse effects. Care should be taken to use only the concentration recommended (1/10) as adverse effects to the pumps may occur.

Phenol based solutions

Phenol based solutions are routinely used to clean and disinfect. They come in various forms, such as liquid concentrate and aerosol sprays. Long-term use of concentrates could have harmful effects on the pumps unless used in exactly the dilution strength (in water) specified in the manufacturer's labelling.

CAUTION: Do not autoclave, steam sterilize, ETO sterilise or subject the pump to temperatures in excess of 45° C (113° F). Excessive temperatures may cause damage to the pump.

CAUTION: To prevent serious damage to the pump it must not be immersed in any liquids or exposed to strong organic solvents. Wipe off spills immediately. Do not allow fluid or residues to remain on the pump. Additionally, the pump is not designed to allow it to be sterilised. Failure to observe these cautions may cause internal damage to the pump.

CAUTION: Carry out periodic cleaning following the detailed instructions in this manual. Use only the recommended cleaning agents.

Cleaning agents NOT recommended for use

Activated dealdehydes

Activated dealdehydes are used to disinfect and sterilize medical instruments by immersing them in these solutions. As immersion is required for these cleaning products to be effective, it is **not** recommended that they are used on the pumps.

Alcohol solutions

Solutions of **methyl** alcohol should not be used in cleaning the pumps.

Synthetic detergent with emulsifiers

These cleaning agents are commonly used for routine wipe-down to clean and disinfect. However, long-term use could have adverse effects on the pumps and they are, therefore, **not** recommended.

Iodine-based solutions

Products such as Betadine and Wescadine are commonly used as microbial skin preparations. Long-term use of these products could have adverse effects on the pumps.

Turpene-based solutions

Products which contain Turpenes may also have adverse effects on the pumps if used over a period of time.

Cleaning procedure and precautions

The following cleaning procedures must be followed when cleaning and disinfecting the pumps:

- Unplug the power cord before cleaning to prevent any electric shock hazard.
- Apply all solutions indirectly using a damp cloth.
- Wring out any excess fluid from the sponge or cloth before wiping the pump or power cord.
- Open the door to clean the cassette housing, the inside surface of the door and the door latch.
- Wipe damp spills away immediately to avoid any ‘sticky’ build-up.

Precautions

Observe these precautions when cleaning and disinfecting the pumps:

- DO NOT immerse the pumps in any liquids or apply solutions with a trigger sprayer or under a direct stream or shower, as this will produce too much surface moisture on the pump. This may have a harmful effect on the electronic system.
- DO NOT use steel wool, metallic bristle brushes, plastic abrasive scouring pads, metal spatulas, or other metallic cleaning utensils, as these will scratch the pump housing.

Chemical decontamination procedures

Hospital protocol may require all the pumps used in treatment of hepatitis, AIDS, or quarantined patients to undergo special disinfection procedures. Such procedures are likely to include prolonged (10 minutes or more) contact with disinfecting agents.

Special care must be taken to avoid excess solution invading the pump's internal components. The solutions given previously as **not** recommended for use should be especially avoided during all decontamination procedures.

Recommended yearly checks and tests

The pump should be inspected, lubricated and tested at least once a year, to conform to IEC 60601-1. The initial lubrication and safety checks are described on the opposite page, and the sections that follow.

Once you have carried out all these checks, carry out the functional and accuracy tests that are described on page 7-8.

Carry out lubrication

It is recommended that the cams of the pump should be cleaned once a year, using a paper towel or cotton bud to remove any dirt that may affect the cam life.

Once clean, apply a small amount of the recommended lubricant (see below) to each cam. Run the pump at a fast rate whilst lubricating to ensure good coverage of the cam and the follower

DO NOT lubricate the encoder cam wheel.

Recommended lubricant

Graseby Medical recommend that the following lubricant should be used:

- 'STP Oil Treatment', available from most car accessory outlets, and manufactured by First Brands Europe Limited. Also available from Graseby Medical, part number 6835 0510

This non-organic product has a good general coating performance, and has proved to be safe with various plastics.

Check pole clamp screws

With the case open for the lubrication procedure, it is recommended that the four screws holding the pole clamp in place should be checked. These screws should be tightened to a torque of 180-190 cNm. This is particularly relevant in areas where the modular connection system is employed regularly.

Check pump condition

Inspect the pump to check that it is in good condition as follows:

1. The safety information and operating instructions on the side of the pump must be legible.
2. The mechanical conditions of the pump must allow safe operation.
3. The pump must be clean.

Carry out electrical safety checks

Check that the pump operates within the electrical safety ranges described here:

1. The safety fuses must be of the specified type and rating.
2. Ground impedance between the protective contact in the AC mains plug and the potential equalisation terminal must be equal or less than 0.2 Ohm.
3. Ground impedance between the protective contact in the pump inlet and the potential equalisation terminal must be equal or less than 0.1 Ohm.
4. The leakage current meets the specification.

Recommended annual functional and accuracy tests

The pump should be inspected, lubricated and tested at least once a year, to confirm to IEC 60601-1. The initial checks and lubrication are described on the preceding pages.

Once you have completed the initial checks, you must carry out the functional and accuracy tests that are here.

To perform these tests, a suitable drain-away system must be available for expended fluid. Use only a 20 drops/ml non-checkvalve set, and sterile water or normal saline as the solution. Verify the pump is switched for primary operation before commencing the check.

A sample checklist is provided as a record keeping suggestion (see page 7-18) and the paragraph numbering given below corresponds to the numbers in the check list.

WARNING: Do not perform these tests while the pump is in use on a patient, as this may cause patient injury or death.

1. Power up/self test

With the AC power switched on and the power lead connected to the pump, verify that the green LED (charge) lights.

Note: The green LED only lights when the pump is plugged into a live AC outlet.

Turn the pump on and verify that all the LEDs light, and all the segments in the rate and volume to be infused displays are lit briefly (8s appear in all digits).

Verify that the hold LED is lit continuously, and also that the primary LED is lit.

Verify that the Message Display briefly shows a checkerboard pattern, the backlight is on, and the display shows a screen something like this:

2. LCD contrast/LED brightness

Verify that the Message Display is readable from an angle of approximately 20 degrees above and below.

Cover the photo sensor and verify that the LED display intensity decreases.

Now uncover the photo sensor and verify that the LED display intensity increases.

3. Keypad/memory

For Version 0.71 software, the function checks will depend on the options configured.

Load the pump with a fluid filled administration set

Verify that the ***Primary*** LED is lit. Program a rate of 56.7 mL/h, and enter a volume to be infused of 123.4 mL.

Press ***Secondary*** and verify that the secondary LED lights. Program a rate of 980 mL/h (98.0 mL/h on 3100/505), and a volume to be infused of 1.0 ml (0.1 ml on 3100/505).

Press ***Run*** and unplug the pump's power cord. Verify no loss of power or disruption of operation occurs (pump continues operation under battery power).

Verify that the volume to be infused display decreases by 0.1 ml increments, and that the volume shown in the Message Display (**ml this infusion**) increases by 0.1 ml increments.

Verify that the pump switches to primary after 1.0 ml (0.1 ml on 3100/505) has been infused under secondary operation. Verify that the primary LED lights, two repetitions of the ***non-insistent*** audio alarm sound, and the Message Display backlight flashes to coincide with the audio alarm.

Verify that the primary rate of 56.7 mL/h, and the volume to be infused of 123.4 ml are displayed.

Verify that the volume to be infused display decreases by 0.1 ml increments, and the volume shown in the Message Display increases by 0.1 ml increments.

While the pump is running, press ***On/Off*** and verify that the pump does not turn off. Press ***Hold***.

Observe and record the rate and volume to be infused values. Turn the pump off, then on, and verify that the recorded display values return, unchanged.

Press ***Volume to be Infused*** and verify that the volume shown in the Message Display goes to zero, and the volume to be infused display goes blank. Wait approximately 10 seconds, and verify both displays return to their original values.

Press ***Volume to be Infused*** twice; verify Message Display value goes to zero, and volume to be infused display returns to original value (123.4 ml).

Press ***Secondary***. The Message Display on 3000/500 shows:

(or 0.1 mL on 3100/505).

Rate is 980 mL/h (98.0 mL/h on 3100/505) and volume to be infused display is zero. Press ***Primary***.

4. Keypad lockout button

Press ***Run***, and with the pump running, press the ***Keypad Lockout*** button on the rear housing.

Verify all front panel controls are inactivated, including the ***On/Off*** button, and also verify that the Message Display shows:

```
Keypad locked
```

Press the ***Keypad Lockout*** button, then press ***Hold***; verify that the pump enters hold.

5. Door opening/loading

While the pump is running, open the door and verify:

```
Door open
```

appears in the Message Display and the ***insistent*** audio alarm sounds. Press ***Silence***.

Remove the administration set from the pump, close the door and press ***Run***. Verify:

```
Close clamp!
Load Safety Clip
```

appears in the Message Display and the ***insistent*** audio alarm sounds.

Press ***Silence***.

To avoid possible pump and/or set damage during the next step, close the door slowly.

Open the door and reload the set with the safety clip in its correct position. Before closing the door, close the upper tubing clamp approximately 15 cm - 30 cm (6-12 inches) above the top of the pump. Then close the door and verify that this message:

```
Loading problem
Check tubing set
```

appears in the Message Display and the ***insistent*** audio alarm sounds.

Press ***Silence***.

Open the upper tubing clamp, open the door and load the set correctly.

Close the door and press ***Run***. Verify that the pump operates without alarming.

Press ***Hold*** and then turn the pump off.

6. Over pressure valve

Press and hold ***Options***, then press ***On/Off***.

When the **Enter ID** display appears, enter ***3031***.

When the **Enter Password** display appears, enter ***7867***.

Press ***Options*** until **Pressure Calibrate** appears in display.

Lower the end of the tubing to the floor (approximately 30 inches below the pump).

Program in 100 mL/h (99.0 mL/h on **3100/505**) and run the pump until fluid is flowing from end of tubing. When the motor position value (left side of display) is 1650 ± 50, press ***Hold***.

Watch the end of the tubing for 30 seconds to verify that no more than 1 drop is expelled.

7. Valve integrity

Connect the regulated compressed air source to the lower tubing.

While maintaining the motor position value from step 6 above (1650 ± 50, top valve occluded) apply 12 psi back pressure to the tubing. Verify that no fluid/air movement occurs in the tubing (allow the tubing expansion created by the back pressure to stabilize).

Run the pump until the motor position value is 700 ± 50 (middle valve occluded).

Press ***Hold*** and verify that no fluid/air movement occurs in the tubing (allow the tubing expansion created by the back pressure to stabilize).

8. Pressure plate position micro switch test

Reduce the back pressure and remove the cassette from the pump.

Hang a 2.5" long 0.015" feeler gauge onto the upper left cassette loading pin (gauge must hang within the cassette housing recession).

Close the door and verify that the cassette position number (right-hand side of the display) changes from 0 to 1.

Open the door and remove the 0.015" feeler gauge. Hang a 2.5" long 0.012" feeler gauge in same manner as the 0.15" gauge.

Close the door and verify that the cassette position number (right-hand side of the display) remains at 0.

Remove the feeler gauge from pump.

If the pump fails this test then carry out the adjustment procedure on page 7-32.

9. Audio alarm

Press ***Options*** and advance to the alarm test display. Press ***1*** to test the ***non-insistent*** audio alarm. Press ***2*** to test the ***insistent*** audio alarm, and press ***3*** to test the ***Back Up*** alarm. Turn the pump off.

10. Check occlusion alarm

Refer to Figure 8.14 and section 'Occlusion Alarm Adjustment' (page 8-15) during the following procedures.

Note: For pumps with software Version 0.64 or later, an occlusion filtering process in the Medium and High settings is included. This filtering process causes the pump to pause for up to 10 seconds when an occlusion is detected. There is no filtering process for the Low occlusion setting.

Turn the pump on. Reload the fluid filled cassette (still connected to the compressed air source). Place the lower tubing at the same level as the base of the pump.

Program in a volume to be infused of 888.8 ml and a program a rate of 99.9 mL/h.
Press the ***Occlusion Alarm Setting*** key until the Message Display shows:

```
LOW Occlusion
Alarm Setting
```

Press ***Run*** and slowly increase the back pressure at a rate of 0.1 psi/3 seconds.

Verify that the following display occurs at 2.0 psi +1.0/-0.5 psi):

```
Occlusion
below pump
```

Press ***Silence*** and lower the back pressure below 1.5 psi.

Press ***Occlusion Alarm Setting*** until the Message Display shows:

```
MEDIUM Occlusion
Alarm Setting
```

Verify that the following display appears:

```
Occlusion
below pump
```

and that the pump alarms at 5 psi ± 1.0 psi.

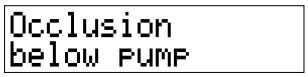
On pumps with occlusion filtering process (see **Note** above), verify that when the pressure reaches 5 psi ± 1.0 psi the motor stops, ***Run*** remains lit and the pumping indicator stops, indicating that the occlusion filtering has begun. Verify that the audible and visual alarms activate within approximately 10 seconds following the start of the filtering process.

Press ***Silence*** and lower the back pressure below 1.5 psi.

Press ***Occlusion Alarm Setting*** until the Message Display shows:

```
HIGH Occlusion
Alarm Setting
```

Press ***Run*** and slowly increase the back pressure. Verify that the following display appears:



and that the pump alarms at 10 psi ± 1.0 psi.

On pumps with the occlusion filtering process (see **Note**, previous page), verify that when the pressure reaches 10 psi ± 1.0 psi the motor stops, run remains lit and the pumping indicator stops indicating that the occlusion filtering has begun. Verify audible and visual alarms activate within approximately 10 seconds following the start of the filtering process.

Press ***Hold***.

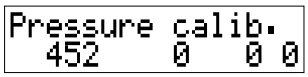
Note: If the pump alarms outside of the specifications listed, see *Occlusion alarm adjustment* on page 8-15.

11. Motor torque

Switch pump ***Off***, hold the ***Options*** key down and switch pump ***On***.

Enter the Biomedical Menu ID as **3031**, then the password **7867**.

Press the ***Options*** key four times, until the screen displays the Biomedical menu pressure display, calibration mode screen:



Press ***Rate*** and enter 35.0 with the number keys.

Apply 9 psi air pressure to the lower tubing and press ***Run***.

Verify that the motor operates without binding for a delivery of at least 6 minutes. Visually check the cassette out going tube for a continuous liquid flow during this period.

Failure may be indicated by a * at the bottom left hand corner of the LCD display and excessive noise and vibration of the motor above the normal stepping action noise. Refer to *Realignment of motor coupler* on page 8-11.

If motor fails to meet test: a 'System Error' message appears in the Message Display and an insistent audio alarm sounds, refer

Press ***Hold*** to stop the motor, then disconnect the compressed air source

Switch pump ***Off*** and then ***On*** again for the next test.

12. Empty bag

Program the pump for a 999 mL/h rate (99.9 mL/h on 3100/505). Press ***Run*** and hang container so that the solution level in the bag is 30 cm (12 inches) above the top of the pump. The top of the pump is defined as the flat area below the handle.

Verify that no alarms occur before the pump has infused 6 mL.

After the pump has infused 6 mL, lower the container so that the solution level is 5 cm (2 inches) above the pump, or 2.5 cm (1 inch) for 3100/505).

Verify that the following display appears and that the pump alarms before 3 mL is infused:

```
No flow
above pump
```

Press ***Silence***.

13. Air detect alarm

Press ***Run*** and invert administration set drip chamber to introduce air into upper tubing. Verify that the pump alarms and displays this message when air reaches the upper cassette chamber:

```
Air in cassette
```

Remove air.

14. Accuracy and KVO alarm tests

Before you start accuracy testing on the pumps:
Obtain a stopwatch to test the rate accuracy.

Obtain a clean 50 mL burette to measure the volume accuracy, and place it on a burette stand.

Obtain the test solution. Use only sterile water or normal saline. Verify test solution is at room temperature (70° F ±5° F).

Hang the solution container so that the fluid level in the container is 45 cm (18 inches) above the top of the pump.

Connect the 50 mL burette to the lower tubing.

Press ***Run*** and operate the pump until the bottom of the fluid meniscus is even with lowest graduation line of burette. Press ***Hold***.

Note: Fluid in burette forms a slight arc. This arc is called the meniscus. All burette readings should be taken from the bottom of the meniscus.

Accuracy test:
Press ***Volume to be Infused*** and enter a volume limit of 49 mL (25.0 mL on 3100/505).

Press ***Rate*** and enter 999 mL/h (99.9 mL/h on 3100/505).

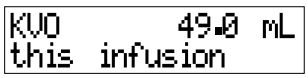
Press ***Run***

Start the stopwatch as soon as the pumping indicator (cursor) in the rate display starts moving.

After the pump has delivered 49 mL (25.0 mL on 3100/505) the ***non-insistent*** audio alarm sounds.

Stop the stopwatch.

Verify that the following display appears in the Message Display:



Confirm that the volume to be infused display is 0.

Confirm that the rate changes to 3 mL/h, or the designated KVO setting in a pump with V0.71 software. Press ***Hold***.

Check the burette and verify a volume of 49 mL ± 1 mL on 3000/500. If checking a 3100/505, verify that the burette holds 25 mL ± 0.5 mL. Remember to take the measurement from the bottom of the meniscus.

Disconnect and drain the burette.

Rate Accuracy:
Check the stopwatch and verify that the alarm occurred at the correct point:

Pump model	*Alarm should occur after...*
3000/500	2 minutes 56.6 seconds ± 3 seconds.
3100/505	15 minutes ± 18 seconds.

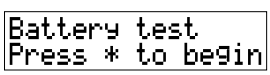
15. Testing the battery

Graseby Medical recommends that the condition of the lead acid battery is checked at least annually

Method 1
When the pump is powered on, the battery is always tested. In addition, the ***Options*** key provides access to the Battery Test option so that the approximate battery voltage can be tested without powering down the pump.

To run the Battery Test:

1. With the pump powered up, disconnect from the AC mains supply and press ***Hold***.
2. Press the ***Options*** key then ***4***, or press ***Options*** until the following message is displayed:

3. Press the * key to start the test. The pump turns on all LEDs, and the rate and volume to be infused displays all zeros to form a known battery load.

The pump then measures the battery voltage. After five seconds the battery gauge displays the approximate battery capacity.

For example, this display would indicate a battery about half charged:

Each **+** indicates increasing battery voltage, as follows:

11.1	+
11.2	+
11.3	++
11.4	+++
11.5	++++
11.6	+++++
11.7	++++++
11.8	+++++++
11.9	+++++++++
12.0	++++++++++
12.1	+++++++++++++
12.2	++++++++++++++++

The display below indicates a fully charged battery:

If the battery capacity is low, you must connect the pump to the AC mains supply to recharge the battery.

It is possible to get a false reading if the battery is in poor condition but has been recently damaged.

The test described above is also carried out automatically when a pump loaded with Version 0.71 software (or later) is switched on, on battery power.

See **Method 2** as an alternative method of checking the condition of the battery:

Method 2

1. Fully charge battery for a minimum 10 hours. Switch the pump on and load a standard cassette.
2. Disconnect the pump mains lead from the AC power supply. Set a rate of 100 ml/hr (99.9 ml/hr for 505/3100) and a VTBI of 999ml.
3. Allow the pump to run until it alarms 'Low Battery Plug In Cord'.
4. Allow pump to run through these alarms (alarms can be silenced if needed) until it triggers 'Battery Too Low Plug In Cord' alarm.

5. Using the Volumetric Event History Download Software confirm that the times up to the first 'Low Battery Plug In Cord' alarm, and time difference between this alarm and the 'Battery Too Low Plug In Cord' alarm, is within the following specification.

Pass:

A battery shall be deemed to have passed its test if the unit runs for a minimum of 51/2 hours on DC power, at a rate of 100ml/hr (99ml/hr for 505/3100) before the first 'Low Battery Alarm Plug In Cord' is triggered.

There must be a minimum of 30 minutes between this alarm and the 'Dead Battery Plug In Cord' alarm that will occur before the pump powers down.

In use this 30 minutes would allow up to 5 sets of 'Low Battery Plug In Cord' alarms to be raised. When cancelled the 'Low Battery' alarm will be triggered again every 6 minutes if the AC power supply has not been connected.

Fail:

A faulty battery would be one that does not meet this specification. In this case the battery should be replaced.

It is recommended that pumps should be run overnight as this would avoid creating a disturbance to staff caused by the 'Low Battery Plug In Cord' and 'Dead Battery Plug In Cord' alarms that occur before the unit's power down.

Event history should then be downloaded and analysed to confirm that the battery time periods meet the requirements above.

Recommended Functional & Accuracy Tests: Checklist

(Tests should be carried out every 12 months)

Date: _____Model #: _____ Serial Number: _____

Other ID #: _____ Tested by: _____

Test No.	Function	Checked	Notes
1.	Power up/self test	_____	
2.	LCD contrast/LED brightness	_____	
3.	Keypad/memory	_____	
4.	Keypad lockout button	_____	
5.	Door opening/loading	_____	
6.	Over pressure valve	_____	
7.	Valve integrity	_____	
8.	Pressure plate sensor open	_____	
9.	Audio alarm test	_____	
10.	Occlusion alarm setting:		
	Low	_____	
	Medium	_____	
	High	_____	
11.	Motor torque	_____	
12.	Empty bag	_____	
13.	Air detect	_____	
14.	KVO/accuracy	_____	
15.	Battery Test	_____	

Troubleshooting

This section assumes that the user has already attempted to correct the alarm condition as detailed in *Troubleshooting, Chapter 4* of the Instruction manual.

This section details troubleshooting procedures in two tables:

- Table 7.2 lists error code related events and gives suggested causes/solutions. If a fault occurs, refer to Chapter 3, Biomedical Menu, for instructions on how to enter this menu to find the error code number.
- Table 7.3 lists problems and possible corrective actions not specifically related to error codes.

This section provides additional information on:

- Replacing LCD screen
- Reinitialising the pump after a NV RAM replacement

It is recommended that you maintain a complete set of properly functioning circuit boards for each pump model you have. Extra boards are useful for diagnostic troubleshooting when circuit board repairs are indicated. Electronic malfunctions should be narrowed to a specific circuit board.

WARNING: Unplug the AC power cord before opening the pump housing to avoid risk of electric shock, which could result in death or serious injury.

WARNING: Potentially dangerous voltages are exposed when the pump housing is open and the AC power cord is plugged in. These voltages are present in the following areas. The transformer and AC fuse on the CPU/Power supply board and the RFI line filter where the power cord connects. To avoid electric shock with potential for severe injury or death, do not touch these areas when the power cord is plugged in.

CAUTION: The functional and accuracy check should be performed following any significant disassembly or repair of the pumps.

CAUTION: Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.

CAUTION: Disconnect the battery connection P104 on I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the On/Off key twice to discharge the circuitry.

CAUTION: The circuit boards consist primarily of surface mounted technology, component level repairs are not recommended.

Table 7.2 Error code related troubleshooting chart

Code	Error/event	Possible cause/solution
10	CPU1 ROM checksum error	Faulty U17 Chip on CPU/power supply board.
12/13	NV RAM error	Pump must be reinitialized, see page 7-25.
14	Main audio alarm failure	Faulty speaker, faulty audio chip (U16), faulty capacitor (C18), or transistor Q8, Q9, Q12, and or Q13 (all on CPU/power supply board).
19	Air detect test failure	Open wires to optical emitter/detector, faulty emitter/detector, faulty transistors Q102, Q106 on I/O Board, contamination/debris blocking optical emitter/ detector path.
20	No flow above pump circuit error	Empty bag contact out of adjustment (must be calibrated at the Service Centre).
21	Display board communication error	Fluid contamination on Display board - replace board and perform 'Occlusion Alarm Adjustment'. Faulty resistors R29, R87, R92, R93 on CPU/power supply board, faulty ribbon cable connection (P200) on CPU /power supply board.
22	Display digit, 0-9	Voltage to LED's on display board too high or too low, Replace display board and perform 'Occlusion Alarm Adjustment'.
23	Display LED error, 0-6	Either Hold, Run, AC, Battery, Primary, or Secondary LED faulty.
28	Motor stall/interrupter	Loose motor coupler.
31	Micro/Macro discrepancy error	Incorrect jumper configuration - jumper JP10 should be removed /open for 3000/500, intact/shorted for 3100/505 (if the JP10 jumper configuration must be changed, the pump history must be reconfigured at the Service Centre).
32	Pressure plate position switch change during RUN	Check Pressure plate position switch calibration (refer to pressure plate position sensor breakopenpoint in functional test), inspect door and hinges for damage.
33	Corrupted triple redundant variable in NVRAM	Pump must be reinitialized, see page 7-25.
38	NV RAM error	Pump must be reinitialized, see page 7-25.
40	Pressure plate position switch = 1 when door is open	Check pressure plate position switch calibration (refer to pressure pressure plate position sensor breakopenpoint in functional test).
42	Safety clip in place when door	Cam housing switch out of adjustment.
43	Service due	Service due date reached. Service pump/reset service due date.
65	Stop pumping - occlusion	Refer to 'Occlusion alarm adjustment'.
67	Stop pumping - no flow above pump	Empty bag contact out of adjustment (must be calibrated at the Service Centre).
69	Stop pumping - loading problem	Check pressure plate position switch calibration (refer to pressure plate position sensor breakopen point in functional test), check motor connection to I/O board at P103.
72	Stop pumping - Safety clip	Check motor connection to I/O board at P103, check wire connection to Safety clip switch.

Table 7.3 Symptom/cause troubleshooting chart

Symptom	Possible cause/solution
No backlight in message display.	Faulty transistor Q401 on Display board, faulty LCD board. On EL backlit units the DC to AC inverter U401 may be faulty.
Pump works on AC with no alarm.	Faulty transistor Q2 on CPU/Power supply board, but continuous audio alarm on DC open battery fuse F101 on I/O board.
No AC LED indicator.	Open resistor R110 on CPU/Power supply board.
Pump blows AC fuse.	Faulty diode D6 and/or D7 on CPU/Power supply board.
Battery and AC LED indicators are both on when there is no AC power.	Faulty diode D12 on CPU/Power supply board, inductor L1 on CPU/Power supply board open.
AC LED indicator is on when there is no power.	Faulty U22 (18 Volt regulator) on CPU/Power supply board.
Battery LED indicator does not light when pump is operating on battery and unable to perform "Battery Test Optional Function".	Open resistor R122 on CPU/Power supply board.
"Keypad Locked" message cannot be deactivated by the Keypad Lockout button on the back of the pump.	Faulty capacitor C48 on the CPU/Power supply board.
Pump non operational when AC power is removed.	Replace open battery fuse F101 on I/O board, replace battery, repair faulty wire connection between battery and P104 on I/O board or replace wire assembly, faulty Q2 on CPU/Power Supply board.
AC LED is not lit when AC power is on but battery LED is lit.	Replace open AC fuse F1 and/or F2 on CPU/Power supply board, repair faulty wire connection between RFI line filter and CPU/Power supply board, open thermal fuse within transformer - replace Power supply/CPU board, replace faulty AC power cord.
Battery and Charge lights both lit, battery will not charge.	Faulty 18 Volt regulator (U22) on CPU/Power supply board, faulty U109 on I/O board, replace faulty battery.
Dead battery alarm (battery too low, plug in cord).	Go to options screen and perform battery test - if battery is low, charge battery, JP402 on Display board disconnected - repair connection. Faulty U408, A to D converter on Display board.
Low battery alarm (Low battery, plug in cord).	Go to options display and perform battery test - if battery is low, charge battery, faulty U415 on Display board, faulty U408 (A to D converter) on Display board.
No keypad response.	Repair faulty connection between membrane switch and Display board, replace faulty membrane switch, faulty resistors R29, R87, R92 and R93 on CPU/Power supply board.
Pump will not switch on	If the pump is connected to AC power, check that the safety keypad lockout feature has not been activated. Press the keypad lock button at the rear of the pump to disable this feature.
Air in cassette.	Cassette loaded in backwards (flat side in) - reload cassette, replace faulty optical detector and emitter, faulty U103 and/or U107 on I/O board.

Symptom	Possible cause/solution
Loading problem, check tubing set	Cassette loaded in backwards (flat side in) - reload cassette, repair faulty connection to pressure plate micro switch, faulty U414, U409 on Display board, (motor is stalling in reverse - repair motor wire connection at P103 on I/O board, replace I/O board, replace Display board, replace motor).
	Display the Pressure Calibrate screen in Biomedical menu. Check that with the pump running and a set loaded, the motor position value increments from 0 - 1919 and that the pressure value is between approximately 23 and 37 for a closed loop cycle. If the motor position displays 'unref' then replace the faulty opto encoder on i/o board. If the pressure value is out of spec, adjust occlusion alarm setting or replace faulty pressure transducer.
No flow, above pump.	Repair faulty P102 connection on I/O board, repair open empty bag contact wire - repair wire, contact out of position - reposition contact in guide slot, faulty U104, U105 on I/O board, contaminant on top piston shaft - clean top piston shaft.
Back up/continuous audio failure.	Replace open fuse (F101) on I/O board, loose fuse (F101) - tighten fuse holder contact.
Occlusion, below pump.	Faulty pressure sensor - replace pressure plate, repair faulty wire connection to pressure sensor, repair faulty connection to J404 on Display board, faulty U409 on Display board.
Close clamp, load safety clip.	Replace faulty flex wedge micro switch (see Fig. 7.7), repair faulty wire connection to flex wedge micro switch, repair faulty connection at P102 on I/O board, faulty U104 on I/O board.
Door open.	Replace faulty cam housing micro switch, repair faulty wire connection to cam housing micro switch, repair faulty connection at P102 on I/O board, faulty U104 on I/O board.
Primary audio failure (***Back Up*** audio sounds, system error is displayed).	Replace CPU/Power supply board. Faulty U16, Q12, Q13 on CPU/Power supply board.
Primary audio failure (primary audio sounds, system error is displayed).	Replace CPU/Power supply board. Faulty U5, U10, U11 on CPU/Power supply board.

Replacing the LCD

If it is necessary to replace a pump's LCD (LED backlit), you must first establish if the pump is fitted with the older 'EL type' display.

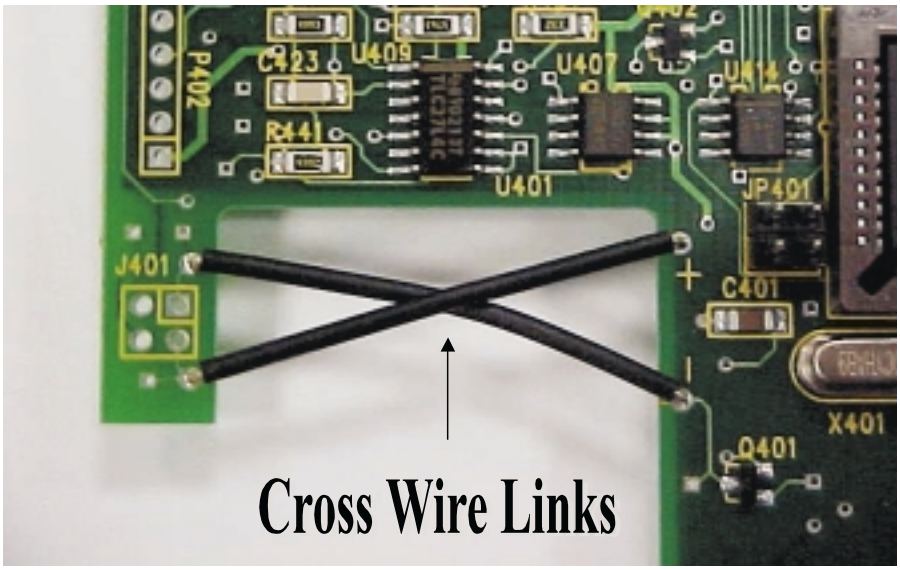
This section explains how to identify an EL type display and how to carry out the necessary modifications to the display board.

Note: Graseby Medical recommends that the technician responsible for carrying out this work should have had relevant training, be familiar with servicing this type of product and should be aware of all associated precautions. Full instructions for disassembly and assembly of the pump are given later in this chapter.

Identify the LCD type

You need to check on the display board to identify the LCD type. To allow access to both the display board and the LCD:

1. Remove the four screws in the rear door of the front door assembly
2. Remove the two holding screws in the door handle assembly
3. Look on the display board, position U401.



If two wire links have been fitted as shown here, the LCD can be directly replaced without any further modification. Follow the instructions that are supplied with the replacement LCD.

However, if an Inverter is fitted at position U401, the display is the EL type, so you must:

- Modify the display board as described over the page, to allow a replacement LCD to work correctly with the 5-volt supply.
- Replace the door front, door rear, pressure plate springs and spring brackets, to accommodate the new LCD which is larger than the old EL type. See over the page for a list of the replacement components and their part numbers.

Modify the display board for EL type display

If the LCD is the EL type, you must modify the display board by removing the inverter and replacing it with two wire links, so that the new LCD works correctly with the 5-volt supply.

Note: For this procedure, you need solid tinned copper wire and PTFE sleeving. These items are not available from Graseby Medical, but can be obtained from most electronics stores, for example, RS Components. The RS part numbers for the items are:
Tinned copper wire 22 s.w.g. RS part number 355-079
PTFE 0.89mm bore diameter RS part number 399-805.

1. Remove the Inverter at position U401 by carefully de-soldering the four pins. Ensure that you do not damage the solder pads around the through holes in the board.
2. Cut two wire links each 44mm long, from a length of solid tinned copper wire (22 s.w.g).
3 Cut two 35mm lengths from clear PTFE sleeving (0.89mm bore diameter).
4. Wrap each wire link in a length of the PTFE sleeving.
5. Fit the two wire links diagonally across the space at position U401, as shown in the diagram on the previous page.

CAUTION: The crossed wires must be shielded with suitable insulation as described. Failure to carry out the procedure as specified may result in permanent damage to the LCD.

Replacement components for EL type display

Once you have modified the display board, you must fit the new LCD. You also need to replace the Door Front and Door Rear assemblies as the replacement LCD is larger than the old EL type. Order and fit either the conversion kit, or the LCD and both the front and rear assemblies shown in this list:

Part name *Contents*	*Part numbers for model 3000/500*	*3100/505*
Display Conversion Kit LCD Display Door Front Assy Door Rear Assy Instructions	0150-0503	0150-0522
Door Front Assy Kit Door Front Keypad Keypad Overlay Over Label Lower Door Recess Label	0150-0501	0150-0502
Door Rear Assy Kit Rear Door Gasket Spring Brackets x 2 Pressure plate springs x 4	0150-0504	0150-0504

Reinitialising the pump after replacing the NVRAM (IC18)

If the pump displays a fault service code indicating NV RAM failure, (System error codes 12,13,33 or 38) then the most likely cause is that the RAM has suffered a premature failure of its internal battery. Should one of these errors occur, then the NV RAM (IC18) must be replaced.

Once the replacement NV RAM has been installed and the unit has been re-cased, the CPU must be reinitialised following instructions in this section.

Note: There are three different sets of instructions, for Version 0.53 software, Version 0.63 software and Versions 0.65/0.67/0.71 software. Ensure that you follow the appropriate set of instructions for the pump's version of software.

After completion of the initialisation, Graseby Medical recommend that a full functional test as described on page 7-7 should be carried out before the unit is returned to operational use.

NV RAM U18 Part Numbers

28 Pin 2706-0265 Type MK48T18-150PC1

24 Pin 2706-0275 Type MK48T12-150PC1

CPU board initialisation for Version 0.53 software

Follow these instructions for initialising a pump fitted with **version 0.53 software only**.

Connect the pump to the AC Mains supply

ON + (.) KEY or Period Key

Enter ID: 7-7-7-Run-Run-Run

Password: 2-1-2-1

Press ***Options*** key once

Switch off the pump

ON + ***Options*** key

ID: 3-0-3-1

Password: 7-8-6-7

Scroll through all displays by pressing the ***Options*** key

Switch off the pump

ON + ***Occlusion*** key

ID: 7-5-5-7

Password: 3-7-9-6

Continued over the page

CPU board initialisation for Version 0.53 software *continued*

Press the ***Options*** key once and enter the start-up parameters.

Using the **1▼** and **3▲** keys, enter and confirm the following parameters:

PRESSURE SAMPLE START = 15

BACK-OFF PRESSURE = 20

After entering Back-Off pressure:

Press the ***Options*** key once and check the TIME and DATE. Enter a new time and date if necessary (set time to GMT) using the numeric key pad.

Press the ***Options*** key twice and set RATE CALIBRATE to 0.0% using the up arrow (1) and down arrow (3) keys.

Press the ***Options*** key 5 times to display the PUMP ID (serial number) screen. Enter the serial number as follows:

Press the * key first, then use the numeric keypad to enter 3000 followed by the serial number.

Press the ***Options*** key once to display the CLEAR PUMP HISTORY screen. Press the * key twice to clear the pump history.

Switch off the pump.

Pump initialisation is now complete.

7

CPU board initialisation for Version 0.63 software

Follow these instructions for initialising a pump fitted with version **0.63 software only**.

Connect the pump to the AC Mains supply

Hold down the Period Key (.) and press ***On***

Enter ID: 7-7-7-Run-Run-Run

Password: 2-1-2-1

Press ***Options*** key three times to get the following screen:

"Press * to Enable SI keys"

Press the * key once and ensure resulting screen reads:

"Press * to Disable SI Keys"

Switch off the pump.

Continued ...

CPU board initialisation for Version 0.63 software *continued*

Special Functions

Hold down the * key and press ***On***.

Enter ID:
1-3-9-7-5-*-PRIMARY-SILENCE-RATE-SECONDARY-TOTAL VOLUME

Enter password:
VTBI-0-2-0-4-0-8-1-0-OCCLUSION ALARM SETTING-PERIOD(.)

To enable VOT , press *. Screen then reads:

"Press * to Disable VOT"

Press the ***Options*** key once.

To enable Dosing, press * once. Next screen reads

"Press * to Disable Dosing".

Switch off the pump.

Biomed Special Functions

Hold down the ***Options*** key and press ***On***.

Enter ID: 3-0-3-1

Enter Password: 7-8-6-7

Scroll through all displays by pressing the ***Options*** key

Verify that VOT and DOSING are turned ON.

Switch off the pump.

Hold down the ***Occlusion*** key and press ***On***.

Enter ID: 7-5-5-7

Enter Password: 3-7-9-6

Press the ***Options*** key once.

"Pressure Sample Start" screen must be showing.

Press the UP arrow once to set to 15.

Press the ***Options*** key once.

"Rate Change Pressure" screen must be showing.

Press the UP arrow once to set to 60.

Press the ***Options*** key once.

"Alt Search Rate" screen must be showing.

Press the UP arrow once to set to 200.

Continued over the page

CPU board initialisation for Version 0.63 software *continued*

Press the ***Options*** key once.

"Search occlusion Pressure" screen must be showing.

Set to 123 using the arrow keys.

Press the ***Options*** key once.

"Search Halfstep Limit" screen must be showing.

Press the UP arrow once to set to 920.

Press the ***Options*** key once.

Press the arrow keys as needed until "Back Off Method: Rev to Pr + Steps" shows.

Press the ***Options*** key once.

"Back Off Pressure" screen must be showing.

Press the UP arrow once to set to 20.

Press the ***Options*** key once. The screen must read

"Rev to Pos range".

Press the UP arrow once to change the first four digits to 1340.

Press the * key once.

Press the UP arrow once to change the first four digits to 1500.

Press the ***Options*** key once

Enter a new time and date if necessary (set time to GMT) using the numeric key pad.

Press ***Options*** key again until you come to the PUMP ID (serial number) screen. Enter the serial number as follows:

Press the * key then use the numeric keypad to enter the pump serial number (all 9 digits).

After the serial number is input, the "Clear Pump History" screen will appear.

Press the * key twice to clear the pump history.

Switch off the pump.

Pump initialisation is now complete.

CPU board initialisation for Version 0.63 software continued

Resetting or verifying the Rev to Pos Range

After the "Rev to Pos Range" screen has been initially set, the option to set it or verify it will not automatically come up as you step through the screens.

Use the following procedure to reset or verify:

When you get to the "Back off Method: Rev to Pr + Steps" screen, press the DOWN arrow once.

The "Back off Method: Rev to Pos Range" screen will appear.

Press the ***Options*** key TWICE.

The "Rev to Pos Range" screen will appear and can be changed if necessary. After it has been changed or verified,

Press the ***Options*** key until the "Back off Method: Rev to Pos Range" screen appears.

Press the UP arrow ONCE.

The "Back off Method: Rev to Pr+Steps"screen will appear.

The screens are now reset as needed.

CPU board initialisation for Version 0.65 / 0.67 / 0.71 software

Follow these instructions for initialising a pump fitted with version **0.65 or 0.67 or 0.71 software only**.

Connect the pump to the AC Mains supply

Hold down the Period Key (.) and press ***On***

Enter ID: 7-7-7-Run-Run-Run

Password: 2-1-2-1

Press ***Options*** key three times to get the following screen:

```
Press * to
Enable SI keys
```

Press the * key once and ensure resulting screen reads:

```
Press * to
Disable SI keys
```

Switch off the pump.

Continued over the page

CPU board initialisation for Version 0.65 / 0.67 / 0.71 software *continued*

Special Functions

Hold down the * key and press ***On***.

Enter ID:
1-3-9-7-5-*-PRIMARY-SILENCE-RATE-SECONDARY-TOTAL VOLUME

Enter password:

VTBI-0-2-0-4-0-8-1-0-OCCLUSION ALARM SETTING-PERIOD(.)

To enable VOT, press * once, or until the screen reads:

```
Press * to
Disable VOT
```

Press the ***Options*** key once.

To enable Dosing, press * once. Next screen reads

```
Press * to
Disable Dosing
```

Switch off the pump.

Biomed Special Functions/ Biomedical Menu

Hold down the ***Options*** key and press ***On***.

Enter ID: **3-0-3-1**

Enter Password: **7-8-6-7**

Scroll through all displays by pressing the ***Options*** key

Verify that VOT and DOSING are turned ON.

Switch off the pump.

Service Functions

Hold down the ***Occlusion*** key and press ***On***.

Enter ID: **7-5-5-7**

Enter Password: **3-7-9-6**

Press the ***Options*** key once.

Enter a new time and date if necessary (set time to GMT) using the numeric key pad.

Press ***Options*** key again until you come to the ID: (serial number) screen. Enter the serial number as follows:

Press the * key then use the numeric keypad to enter the pump serial number (all 9 digits, as they appear on the pump label).

After the serial number is input, the "Clear Pump History" screen will appear.

```
Clear history
complete
```

Press the * key twice to clear the pump history.

Switch off the pump.

For **Version 0.65 / 0.67** software, the pump initialisation is now complete.

For **Version 0.71** software, complete the procedure on the next page.

Technician Menu (Version 0.71 software only)

Hold down the ***Total Volume*** key and press ***On***.

Enter ID: 0-0-0-2

Enter Password: 2-0-2-0

The first item on the menu, Pump ID, must be enabled. If necessary, press * until the screen displays:

Press the ***Options*** key once to reach the Pump ID entry screen. Press the ***Occlusion Alarm Setting*** key.

This sets all the new version 0.71 configurable software features to their default settings:

- The Pump ID screen should now display the same serial number that you entered previously on the Service Functions menu.
- The pump features that are new in Version 0.71 are Disabled.
- The Volume over Time (VOT), Dose Rate Calculation (DRC) and Rate Taper features are Enabled.

The full list of Technician parameters and their default settings are shown in the *Volumetric Technical User Manual*.

Switch off the pump.

For Version 0.71 software, the pump initialisation is now complete.

Adjustment of the 'Cassette Fitted' micro switch (located on the 'Pressure plate assembly')

The adjustment of this micro switch is necessary if the unit fails function test no.8 page 7-11, or if fitting a new pressure plate assembly to the unit.

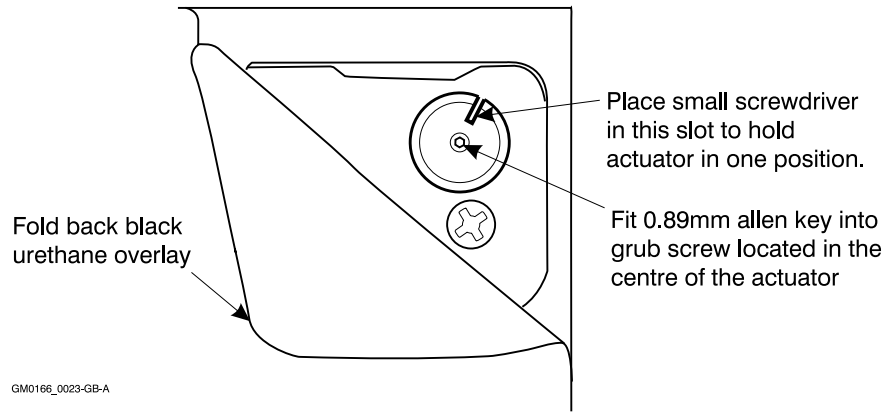
To carry out the adjustment procedure the pump must be in the diagnostic mode. To do this, switch the pump OFF and ensure the pump is on AC power.

Press the OPTIONS key and the ON/OFF key simultaneously.

Enter the ID 3031, then PASSWORD 7867.

Using the OPTIONS key scroll to the Pressure Calibration screen.

On the pressure plate carefully peel back the black urethane overlay that protects the pressure transducer and the micro switch from fluid ingress. Peel the overlay down from the top right hand corner to expose the white round switch actuator.


Place small screwdriver in this slot to hold actuator in one position.
Fit 0.89mm allen key into grub screw located in the centre of the actuator
Fold back black urethane overlay
GM0166_0023-GB-A

Place the 0.89mm allen key in the grub screw in the centre of the actuator and carefully place a small flat blade screwdriver, such as a 2.0 mm precision screwdriver, in the appropriate slot on the edge of the actuator.

Holding the actuator in one place using the screwdriver will allow you to adjust the actuator in or out as necessary by adjusting the grub screw clockwise or anticlockwise.

If the unit displays a '0' on the right-hand side of the display with the 0.015" gauge fitted then adjust the grub screw clockwise.

If the unit displays a '1' on the right-hand side of the display with the 0.012" gauge fitted then adjust the grub screw anticlockwise.

Reposition the urethane overlay or if it has become damaged during the process then replace as necessary.

Unit should display a '1' with the 15" gauge fitted.

Unit should display a '0' with the 12" gauge fitted.

Disassembly/Reassembly & Calibration Instructions

Chapter 8

Disassembly and reassembly instructions

Note: It is recommended that technicians attend a Service training seminar prior to beginning service or repair of this product.

Battery removal

The pumps have a 12 Volt battery (see Fig. 8.1) for short duration use. Unplug the power cord.

Remove the screw which holds the battery door in place, and slide the door towards the bottom of the pump.

Remove the battery clamp and slide the battery partially out of the pump.

Pull the lead connectors from the battery terminals and then remove the battery.

Reverse the above procedure to replace the battery.

AC fuse removal

Unplug pump from the AC power. Remove the battery as described on the previous page.

The AC fuse is located directly above the RFI line filter on the CPU/ Power supply board; it can be removed with long nose pliers.

WARNING: Unplug the AC power cord before opening the pump housing to avoid risk of electric shock, which could result in death or serious injury.

WARNING: Potentially dangerous voltages are exposed when the pump housing is open and the AC power cord is plugged in. These voltages are present in the transformer and AC fuse on the CPU/Power supply board and the RFI line filter where the power cord connects. To avoid electric shock with potential for severe injury or death, do not touch these areas when the power cord is plugged in.

WARNING: Do not perform these tests while the pump is in use on a patient, as this may cause patient injury or death.

CAUTION: The Functional and Accuracy Check should be performed following any significant disassembly or repair of the pumps.

CAUTION: Disconnect the battery connection P104 on I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the *On/Off* key twice to discharge the circuitry.

CAUTION: Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.

Front housing removal

Remove the two screws from the pump handle, one screw from the rear cover near the bottom left corner of AC cord connector cover, and one screw from the battery door on the bottom of the pump (see Fig. 8.1).

Pull the front housing away from the rear housing. Disconnect the battery at P104 of the I/O board.

Press the ***On/Off*** button twice to discharge the circuitry. A deteriorating audio signal is generated. The front housing remains connected to the rear housing by the SPI ribbon cable. This cable must be disconnected from the CPU/Power Supply board (P200) to completely free the front housing assembly.

The front housing is reinstalled by reversing the above procedure, being careful not to damage gasket retainers on the front cover. Before replacing the screws in the housing, perform functional and accuracy check. If the check is satisfactory, complete reassembly.

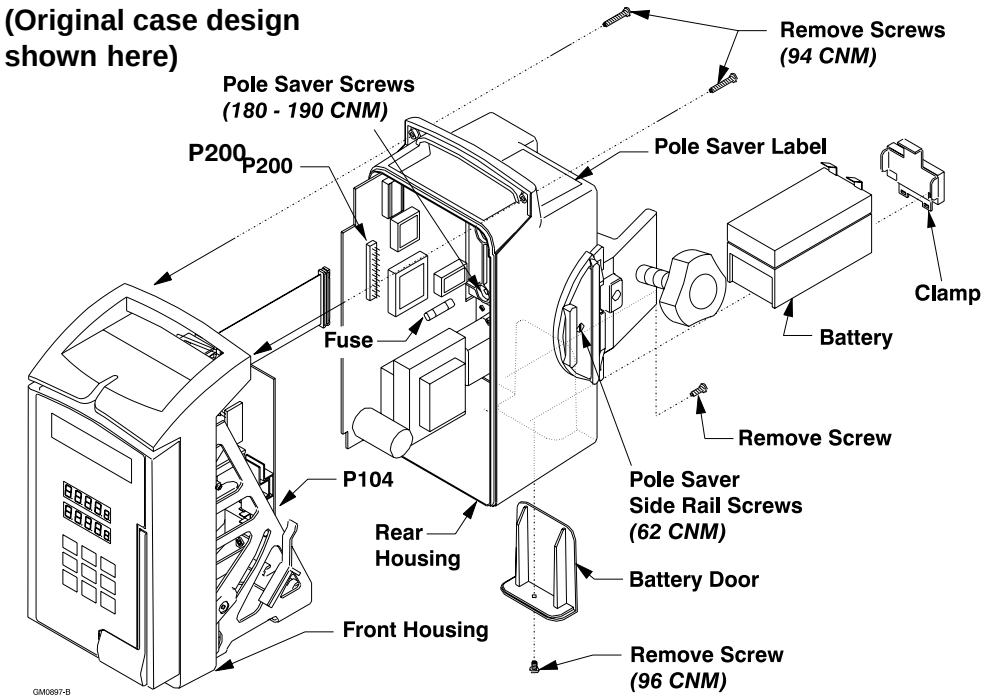


Figure 8.1 Battery and AC fuse removal and front/rear housing disassembly

WARNING: Unplug the AC power cord before opening the pump housing to avoid risk of electric shock, which could result in death or serious injury.

CAUTION: Do not use a screwdriver or other sharp instrument to separate the front and rear housing as this action could cause pump damage.
Disconnect the battery connection P104 on I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the *On/Off* key twice to discharge the circuitry.
Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.

Door assembly removal

First remove the Front housing as detailed above. Open the door.

Remove the two screws from the lower hinge bracket (see Fig. 8.2) and slide the door out. Remove the two screws from the door latch/handle and then remove the handle. Disconnect the SPI cable from I/O board and CPU board. Remove the four screws from the rear door housing. Partly separate the front and rear door housings, then disconnect the wire assemblies from the pressure transducer and pressure plate switch.

To remove the pressure plate assembly, remove the four screws which fasten it to the rear door housing.

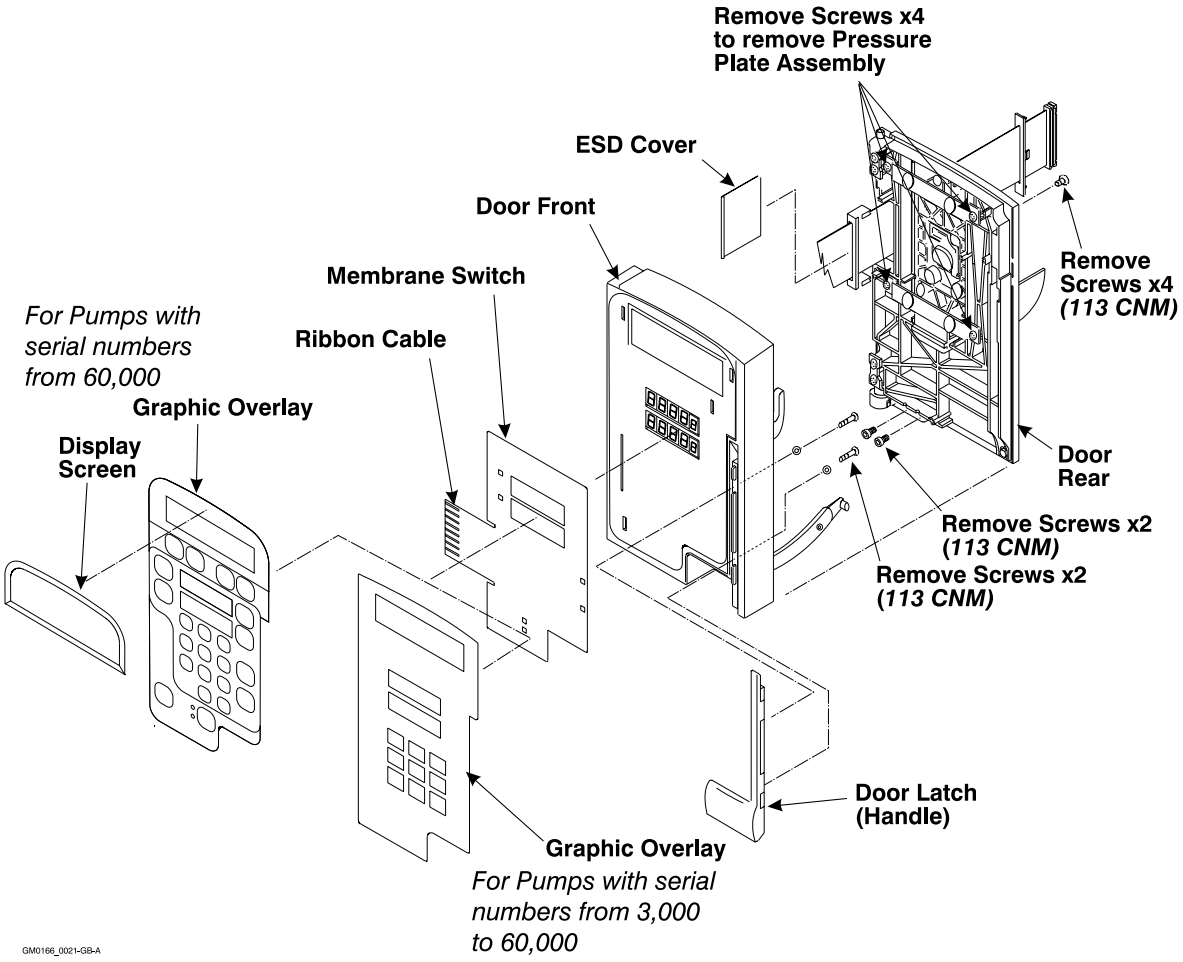


Figure 8.2 Door disassembly

Reassembly

Reverse the above process for reassembly, ensuring that the ESD cover slides into the front pump housing.

Note: For or CE marked pumps only with serial numbers 3000 to 59,999 and for all versions of pumps with serial numbers from 60,000, follow the reassembly procedure on the next page.

Door Rear - reassembly procedure for CE marked pumps ONLY, with serial numbers 3000 to 59,999 and for ALL versions of pumps with serial numbers from 60,000

To ensure ESD protection it is nessessary to follow the following procedure when reassembling Door Rear, failure to do this may result in damage to the LCD and/or Display board.

With the Door, Rear facing you, place a 1.5 inch (38 mm) strip of kapton tape (part no. 26-1011-794-0) and align it to the hinge post and door lip as shown in Figure 8.3A.

Fold the tape down onto the upper hinge bracket and upper spring support as shown in Figure 8.3B. To avoid puncturing the tape it may be nessessary to carefully recess the area shown in Figure 8.3B.

Using the kapton tape again cut a 4.5 inch (114 mm) strip and place the tape horizontally down onto the upper hinge bracket and upper hinge support covering the initial piece of tape, see Figure 8.3C.

Cut another 1.5 inch (38 mm) strip of kapton tape and place on the lower left hand corner of the door, rear (spring support still facing you). The lower hinge bracket should be covered as shown in Figure 8.3D. To avoid puncturing the tape it may be nessessary to carefully recess the area shown in Figure 8.3D.

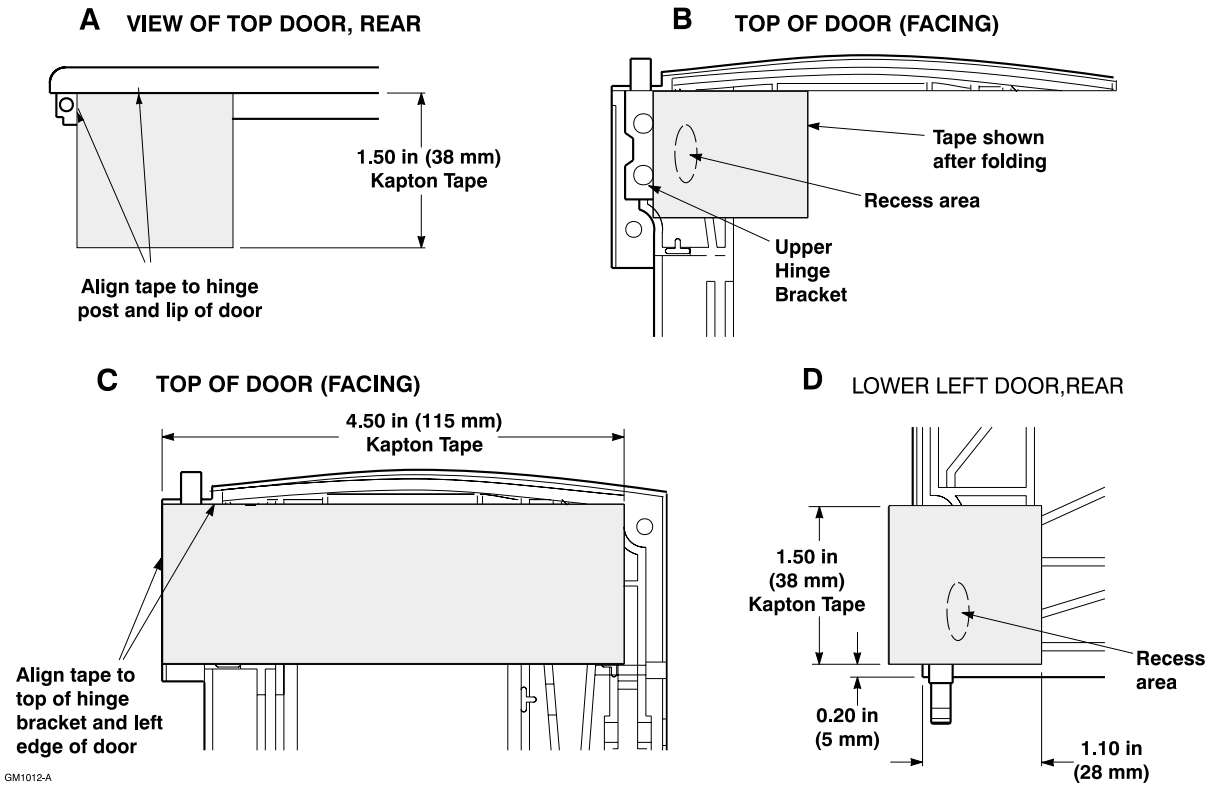


Figure 8.3 Door, rear - ESD protection for CE marked pumps only with serial numbers 3000 to 59,999 and for all versions of pumps with serial numbers from 60,000

CAUTION: **Do not damage or puncture the kapton tape. If the tape is damaged or punctured it could result in the pump not being ESD protected. Special care should be taken when placing the kapton tape and also when assembling the front and rear cases together as the front case lugs may puncture the tape.**

CPU/Power supply board removal

Disconnect the battery connection P104 on the I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the On/Off key twice to discharge the circuitry.

To remove the CPU/Power supply, I/O board, or RS232 board:

Remove the Front housing as detailed above.

Disconnect SPI cable from P200.

On the rear of the pump, remove the threaded Keypad lockout button nut (turn counter-clockwise) and the internal tooth washer.

Remove the audio volume knob and nut.

Remove the two screws from the RS232 connector.

From inside the rear cover, disconnect the brown and blue RFI line filter wires from the CPU/Power supply board.

Slide the CPU/Power supply out of the rear cover.

Reassemble in reverse to the procedures detailed above.

Before replacing the screws in the pump housing, perform the functional and accuracy check. If the check is satisfactory, finalise the housing reassembly.

WARNING: Unplug the AC power cord before opening the pump housing to avoid risk of electric shock, which could result in death or serious injury.

CAUTION: Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.

I/O board assembly removal

First remove the Front housing as detailed on page 8-2.

The I/O board is mounted to the back of the pump assembly. Disconnect the SPI cable from P200 on the CPU/Power supply board and P101 on I/O board. Disconnect motor wire assembly from P103 on I/O board and the sensor wire assembly from P102 on I/O board. Remove the four screws that fasten the board to the pump mechanism.

Reassemble in reverse order.

Before replacing the screws in the pump housing, perform the functional and accuracy check. If the check is satisfactory, finalise the housing reassembly.

WARNING: Unplug the AC power cord before opening the pump housing to avoid risk of electric shock, which could result in death or serious injury.

CAUTION: Disconnect the battery connection P104 on I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the *On/Off* key twice to discharge the circuitry.

CAUTION: Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.

Display board assembly removal

Remove the Front housing as detailed on page 8-2.

Open the door. Remove the two screws from the door latch/handle and then remove the handle. Remove the four screws from the rear door housing.

Separate the front and rear door housings, slightly, then disconnect the wire assemblies from the pressure transducer and pressure plate switch.

Disconnect the SPI cable from the Display board P401 and carefully remove the membrane switch ribbon cable from the Display board J401. Remove the Display board and LCD by carefully bending the retaining nibs (4 off).

Reverse the above process for reassembly, ensuring that the ESD cover slides into the front pump housing and that the rubber seal around the SPI cable is correctly seated.

If a replacement Display board is fitted, the occlusion alarm adjustments (page 8-20) must be carried out prior to using the pump. Also, to obtain satisfactory LCD contrast trimpot R402 (nearest the door hinge) may require adjustment.

Note: If the LCD is to be replaced, you must first identify whether or not the pump is fitted with the older "EL type" display. The procedure for identifying the LCD type, and modifying the display board if necessary, is described in Chapter 7, *Troubleshooting* section.

WARNING: Unplug the AC power cord before opening the pump housing to avoid risk of electric shock, which could result in death or serious injury.

CAUTION: Do not use a screwdriver or other sharp instrument to separate the front and rear housing as this action could cause pump damage.

CAUTION: Disconnect the battery connection P104 on I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the *On/Off* key twice to discharge the circuitry.

CAUTION: Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.

Membrane switch replacement (Original case design)

The Membrane switch consists of two parts; the lower electronic switch, and the upper overlay and keypad graphics. Once in place on the door assembly the two parts are removed as a single unit. The original membrane switch must not be reinstalled because electrical damage during removal could have occured.

The door must be disassembled (see above) in order to replace the membrane switch. With the door assembly open, remove the ribbon connector from P403 on the Display board, then remove the Display board. On the front of the door, peel up and discard old membrane switch. Clean any residual adhesive from the housing.

Follow this procedure to replace the membrane switch:

1. Peel the release liner from the back of the electronic switch (front of membrane switch has raised domes). The release liner on the front of the switch must not be removed at this time.
2. Thread the ribbon cable through the slot provided on the door front.
3. Apply the membrane switch to the door front and press it firmly into place using the fingers. Avoid excess pressure on the actual domes.
4. Once the electrical switch is firmly in place, remove the release liner from its front. Also, remove the release liner from the back of the graphics overlay.
5. Place the graphics overlay over the electrical switch, making sure to line it up correctly with the electrical switch portion. Press firmly around the outer edges, around the display windows, and vertically between the rows of numbers. Avoid excessive pressure on individual keys.
6. Connect the ribbon cable to P403 on the back of the display board. Press board firmly into the board retainers.

Reassemble the door. Perform the functional and accuracy check. If the check is satisfactory, complete the Housing reassembly.

WARNING: Unplug the AC power cord before opening the pump housing to avoid risk of electric shock, which could result in death or serious injury.

CAUTION: Disconnect the battery connection P104 on I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the *On/Off* key twice to discharge the circuitry.

CAUTION: Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.

Membrane switch replacement (Revised case design)

The Membrane switch consists of two parts; the lower electronic switch, and the upper overlay and keypad graphics. In addition, the LCD is covered by a separate LCD window.

Replacement of the keypad, the keypad overlay or the display window must now be carried out as a single unit.

The door must be disassembled (see above) in order to replace the membrane switch. With the door assembly open, remove the ribbon connector from P403 on the Display board, then remove the Display board. On the front of the door, peel up and discard old membrane switch. Clean any residual adhesive from the housing.

Follow this procedure to replace the membrane switch:

1. Peel the release liner from the back of the electronic switch (front of membrane switch has raised domes). The release liner on the front of the switch must not be removed at this time.
2. Thread the ribbon cable through the slot provided on the door front.
3. Apply the membrane switch to the door front and press it firmly into place using the fingers. Avoid excess pressure on the actual domes.
4. Once the electrical switch is firmly in place, remove the release liner from its front. Also, remove the release liner from the back of the graphics overlay.
5. Place the graphics overlay over the electrical switch, making sure to line it up correctly with the electrical switch portion. Press firmly around the outer edges, around the display windows, and vertically between the rows of numbers. Avoid excessive pressure on individual keys.
6. Remove the release liner and place display window into position as guided by the ridge on the front door assembly. Press firmly around the edges of the window.
7. Connect the ribbon cable to P403 on the back of the display board. Press board firmly into the board retainers.

Reassemble the door. Perform the functional and accuracy check. If the check is satisfactory, complete the Housing reassembly.

WARNING: Unplug the AC power cord before opening the pump housing to avoid risk of electric shock, which could result in death or serious injury.

CAUTION: Disconnect the battery connection P104 on I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the *On/Off* key twice to discharge the circuitry.

CAUTION: Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.

Pump assembly removal

The pump assembly consists of the cam housing and the motor assembly. Separation of the front and rear housings, and removal of I/O board are required prior to removing the pump assembly. The pump assembly is separated from the rear housing as follows:

1. Remove the screw from linkage assembly and upper retaining ring from connecting link, remove the link from the pin. Raise the arm of the drop-in guide (see Fig. 8.4) so that the linkage assembly can be removed from the frame assembly.

2. Remove the four screws from cassette housing and lift pump assembly out.

Reverse the above procedure to reassemble the pump to the rear housing. Before replacing the screws in the housing, perform the functional and accuracy check. If the check is satisfactory, complete the Housing reassembly.

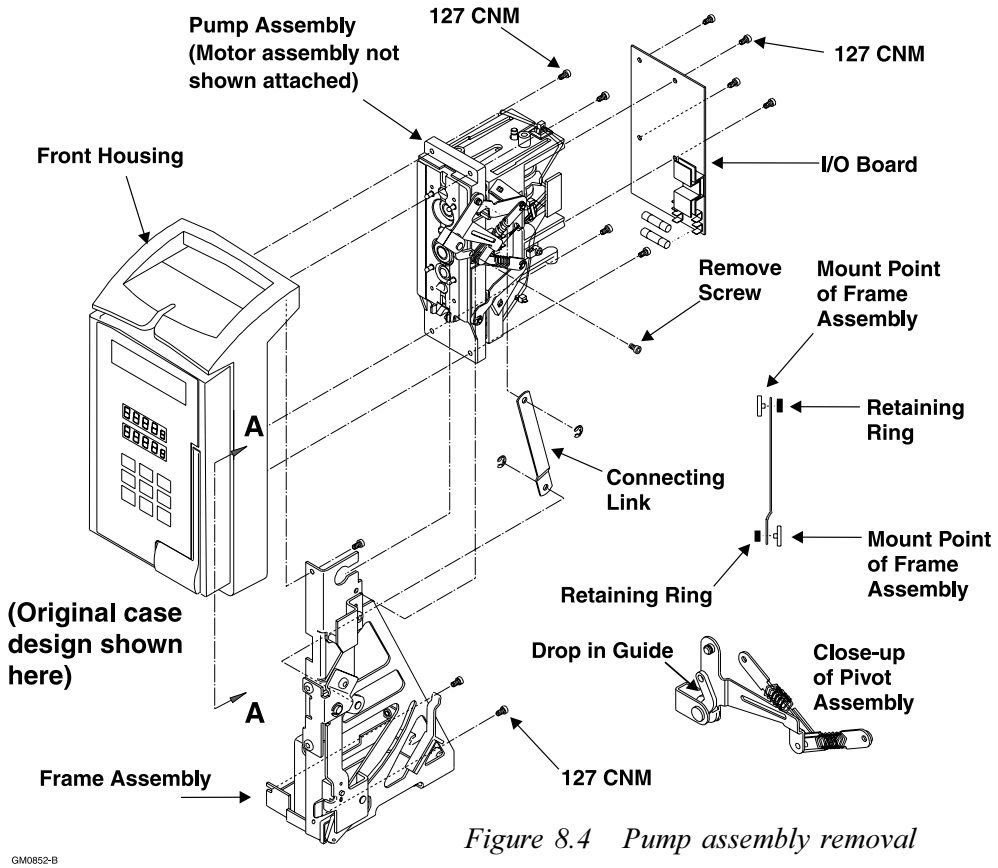


Figure 8.4 Pump assembly removal

WARNING: Unplug the AC power cord before opening the pump housing to avoid risk of electric shock, which could result in death or serious injury.

CAUTION: Disconnect the battery connection P104 on I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the *On/Off* key twice to discharge the circuitry.

CAUTION: Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.

Motor assembly removal

The Front housing, pump assembly and I/O board must be disassembled in order to remove the motor assembly as detailed on earlier pages in this chapter.

Remove the four motor mounting screws (see Fig. 8.4) and take the motor assembly out. Next, remove the swing arm damper from the coupler gear, and remove the coupler gear. Finally, remove the mounting plate with the swing arm assembly intact.

Reverse the above sequence to reassemble. When assembling the motor the swing arm must be properly aligned over the overpressure valve shaft.

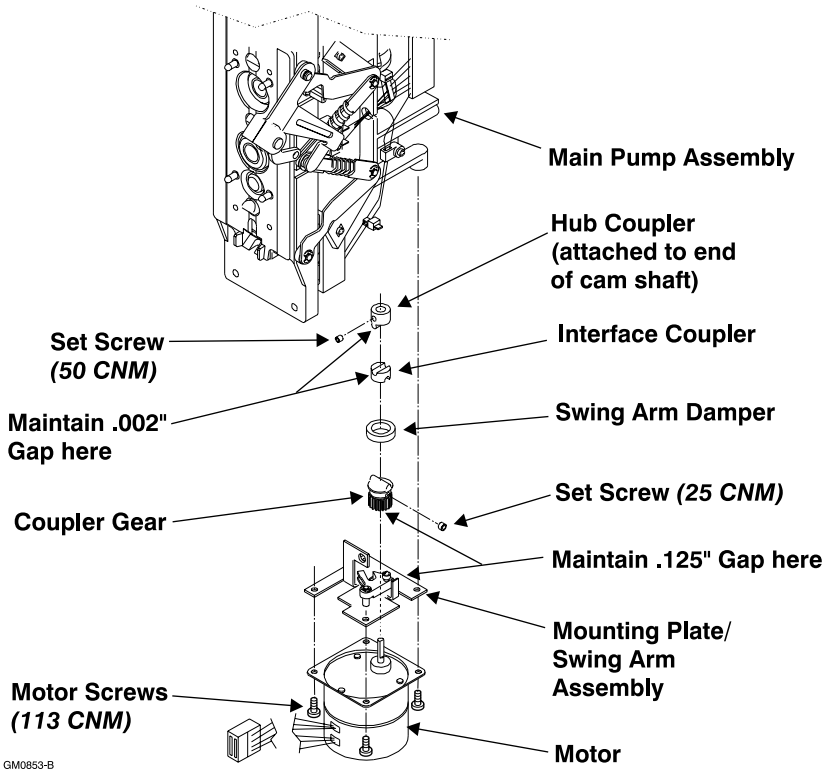


Figure 8.5 Motor assembly

WARNING: Unplug the AC power cord before opening the pump housing to avoid risk of electric shock, which could result in death or serious injury.

CAUTION: Disconnect the battery connection P104 on I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the *On/Off* key twice to discharge the circuitry.

CAUTION: Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.

Realignment of motor coupler

Realignment of the motor coupler is necessary whenever the motor and cam shaft have been disassembled.

The spacing/alignment measurements below are also shown on the diagram on the opposite page.

- A 0.002 inch spacing is required between the hub coupler (attached to the cam shaft) and the interface coupler which is located between the motor sprocket and the hub coupler. You may need to reposition the hub coupler in order to achieve this spacing.
- A 0.125 inch gap must be maintained between the coupler gear and the mounting plate.

Reverse the pump assembly removal procedure to reassemble the pump. Reconnect all cables and the connectors and secure the SPI cable with cable clamps on the left hand side of the pump housing. Reassemble the front and rear housings. Before replacing the screws in the housing, perform the Functional and Accuracy Tests (see Page 7-7). If the tests are satisfactory, complete the Housing reassembly.

Cassette housing disassembly

Prior to disassembling the Cassette housing; the front housing, I/O board and pump mechanism must be removed.

Remove the retaining ring from one end of each cassette shaft. Slide the shaft out of the cassette housing. Remove the optical emitter and detector assemblies from the cassette housing and then remove the cassette housing. Reverse the above procedure to assemble the Cassette housing.

Safety clip mechanism disassembly

The Front housing, pump mechanism, I/O board and cassette housing must be removed in order to disassemble the Safety clip mechanism.

The Safety clip/flex wedge switch is attached to the cam housing (see Fig. 8.6 below). Remove the springs from the cassette housing guides. Disconnect the two wires from the microswitch, then remove the two mounting screws from the cam housing.

Reassembly

Loctite varnistop 7400 must be applied to the surface of the clip switch bracket that mates with the cam housing to assure the strength of the assembly. Before tightening the bracket screws, place the fixture (part no. 78-8069-6343-1) over the cassette housing guide pins and flex wedge to assure alignment, then tighten the screws.

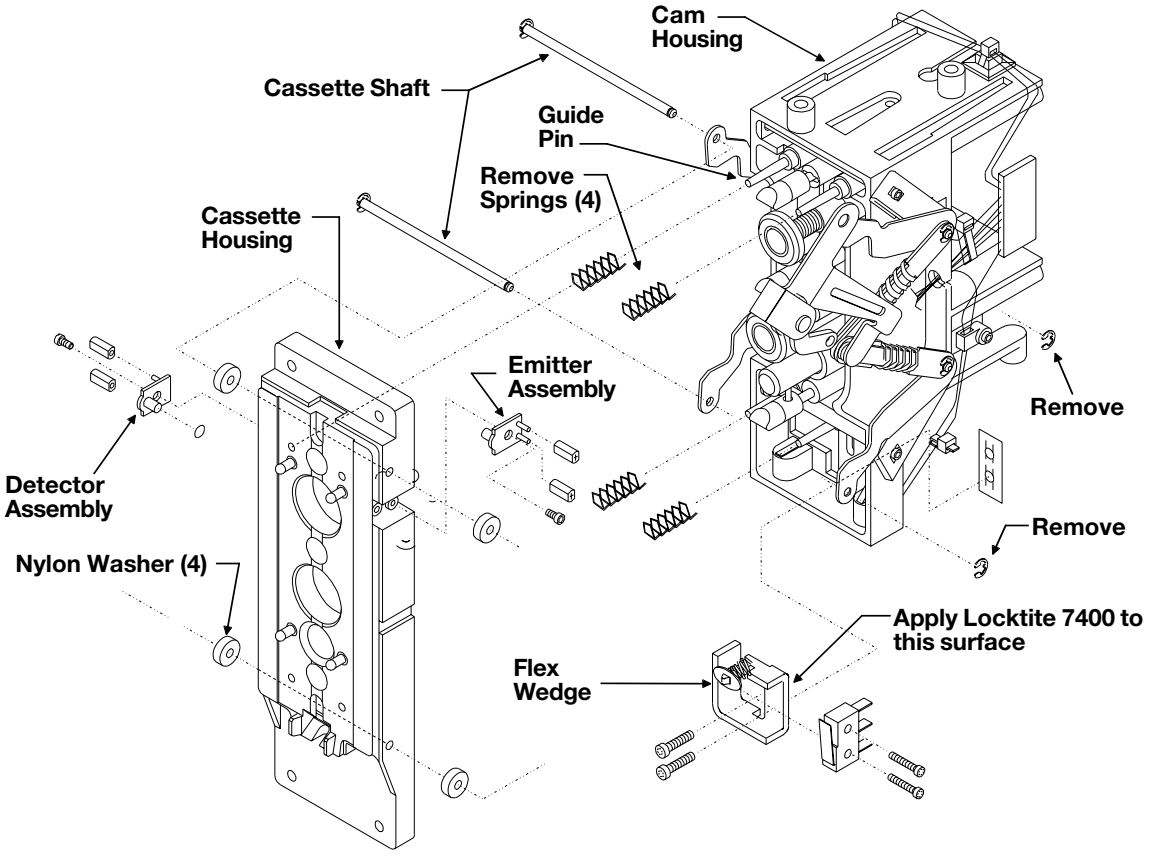


Figure 8.6 Cassette Housing and Safety Clip mechanism disassembly

Cam housing switch disassembly

The Front housing, Pump mechanism, I/O board and Cassette housing must be removed to disassemble the door switch.

Move the linkage mechanism out of the way, disconnect the switch wires and remove the switch plate. Remove the microswitch from the switch plate.

Reassembly

The switch plate must be positioned so that the switch is activated (open) when the cassette housing is bottomed on the cam housing, and 'just' activates when a 0.015" spacer is inserted between cassette housing spacing tab and the cam housing as shown on the diagram below.

Reconnect the linkage mechanism and the switch wires.

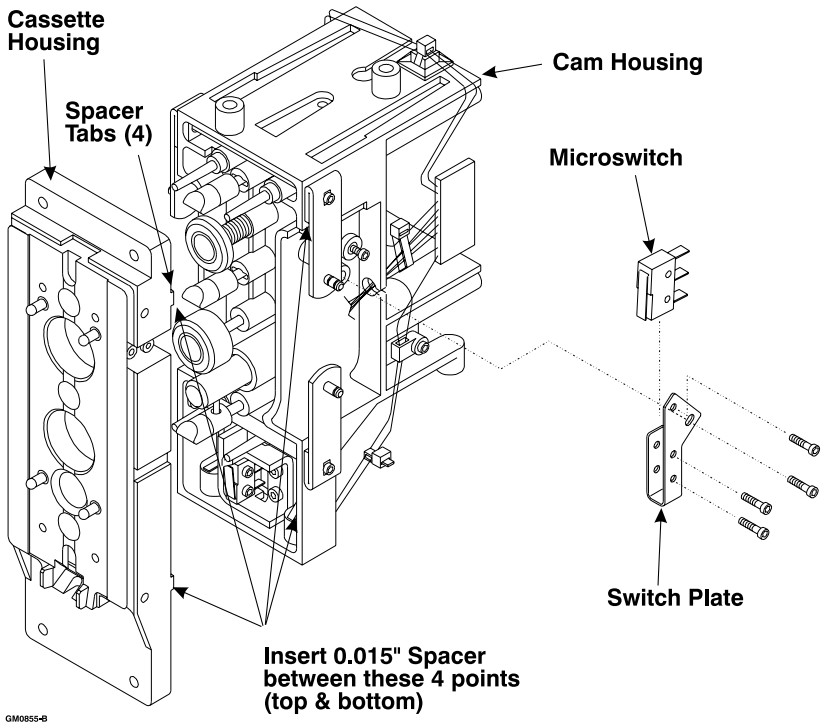


Figure 8.7 Cam housing switch disassembly

WARNING: Unplug the AC power cord before opening the pump housing to avoid risk of electric shock, which could result in death or serious injury.

CAUTION: Disconnect the battery connection P104 on I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the *On/Off* key twice to discharge the circuitry.

CAUTION: Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.

Calibration and adjustment of components

The following calibration and adjustment procedures may be necessary if indicated during the recommended yearly functional and accuracy check. Calibration and adjustment of affected components must also be performed following the disassembly and repair.

Cam housing switch adjustment

The cam housing switch (see page 8-13) acts in conjunction with the Safety clip switch to monitor cassette loading/unloading and Safety clip loading. The cam housing switch is activated when the door is closed and the cam housing moves forward to interface with the cassette housing. The cassette housing causes the switch to open when the door is closed. The switch closes when the door is open.

Calibration of the cam housing switch function is performed by adjusting the position of the switch's mounting bracket. To accomplish this, disassemble the front housing and remove the pump assembly (refer to appropriate sections).

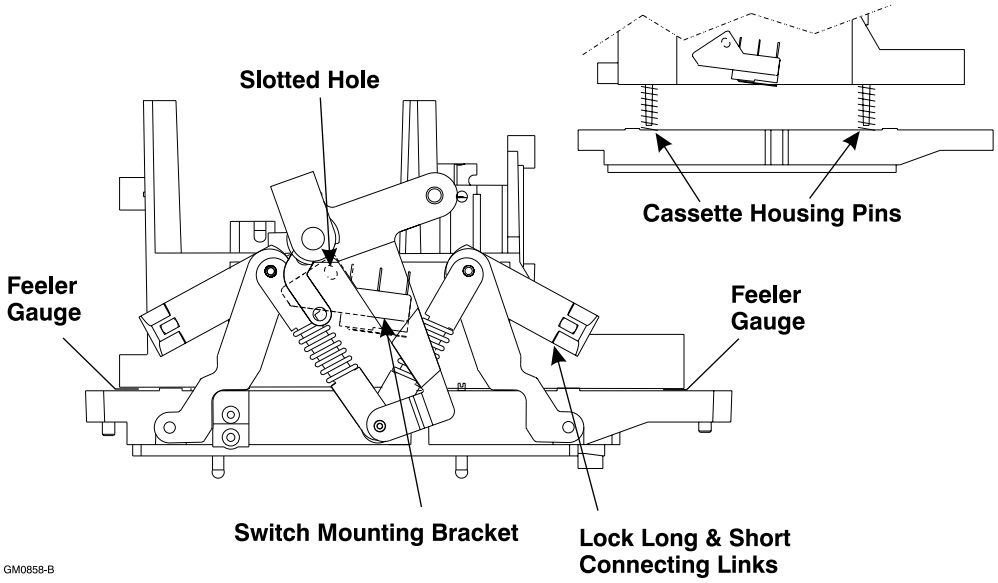


Figure 8.8 Cam switch adjustment

Place a 0.015" feeler gauge between the cassette housing pad and the cam housing at the two points shown, and lock the housings into position by pushing outward on the long and short connecting links. Loosen the two screws that hold the switch bracket to the cam housing, and adjust the position of the bracket so that the switch ***just*** activates. Use an ohmmeter to determine the switch activation. Re-tighten the screws.

Remove the gauges and confirm that the switch is activated when the cassette housing is bottomed on the cam housing. Then re-check that the switch 'just' activates when the 0.015" gauge is inserted between the cassette housing spacing tab and the cam housing as shown.

Occlusion alarm adjustment

The occlusion alarm is produced when pressure develops in the cassette and drives the pressure transducer's A to D conversion to an alarm threshold. The output to the A to D converter is calibrated using trim-pots R439 and R448 at the bottom of the door assembly.

The infusion pumps should be operated against a regulated compressed air source to verify or calibrate the occlusion alarm thresholds. The pressure source must be both adjustable and measurable, for example, the recommended test equipment compressed air source:

- Air regulator which ranges from approximately 2 psi to 12 psi (Bellofram 10-B or equivalent).

The following diagram shows the occlusion alarm adjustment set-up:

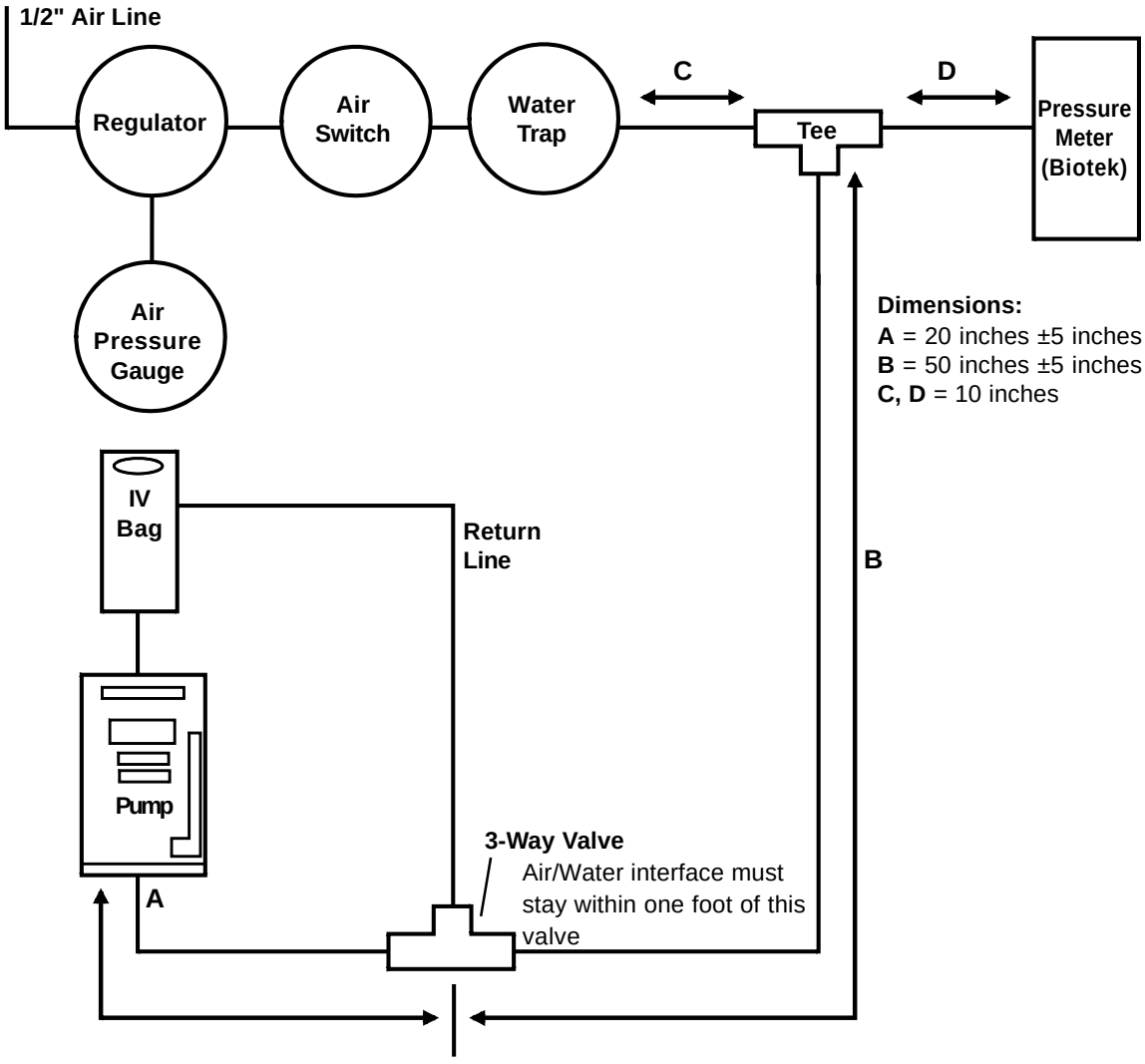


Figure 8.9 Occlusion alarm adjustment set-up

Note: The lower tubing should be placed at the same level as the base of the pump when adjusting the occlusion alarm.

To calibrate the occlusion alarms

Plug the pump into an AC outlet, turn the pump off.

Hold down the ***Options*** key and press ***On***.

Enter ID: 3-0-3-1

Enter Password: 7-8-6-7

Press the ***Options*** key until you see the pressure calibration screen:

Install a fluid filled, 20 drops/ml, non-checkvalve administration set and connect the regulated compressed air source to the lower tubing.

Apply 2.4 psi of pressure, enter a rate of 100 mL/h (99.9 ml/h on 3100/505), and press ***Run***.

Verify fluid movement in tubing, then adjust potentiometer R448 (right-most potentiometer when facing front of pump) until A to D value in Message Display is 45.

Increase the back pressure to 10 psi, and adjust the potentiometer R439 (centre pot) until the A to D value in the Message display is 205.

Repeat 2.4 psi and 10 psi adjustments until the displayed A to D values are stable without further need of adjustment at 45 ±1 and 205 ±1, respectively.

Note: To gain access to the adjust potentiometers the protective label must be removed. A new label should be installed after calibration is complete (Part No. 78-8092-0841-2).

Voltage Checks

Power supply voltage check

Diodes D9, D10 and D11 supply the direct voltage to the pump's logic circuitry. These diodes are shown on the top right hand corner of Figure 10.6. The source power to the logic circuitry is different when the pump is operated on battery than when it is operated on AC power. The following voltage checks verify the proper operation of the above diodes.

16V DC check - power cord connected

Disconnect the pump from the AC power and disconnect the battery cable from P104 on I/O board. Connect a voltmeter to cathode of D11 and TP7 (ground) (TP6 is ground on Dosing boards) on CPU/Power supply board. Plug the pump into the AC outlet and turn the pump on. Verify 16.2V ± 0.6V. Turn the pump off and unplug it from the AC.

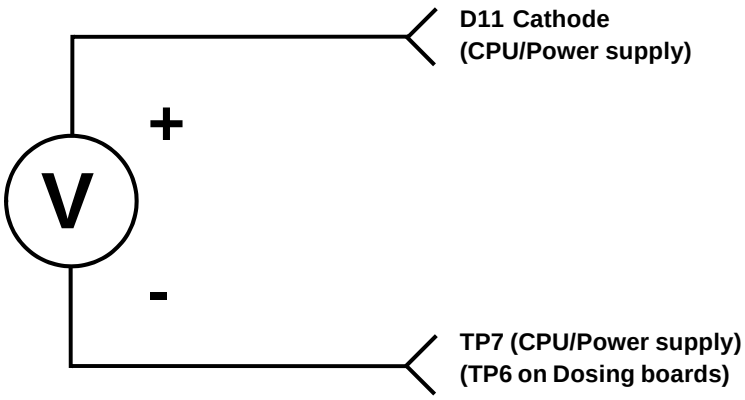


Figure 8.10 16V DC check. Power cord plugged into AC and pump turned on

8

WARNING: Potentially dangerous voltages are exposed when the pump housing is open and the AC power cord is plugged in. These voltages are present in the transformer and AC fuse on the CPU/Power supply board and the RFI line filter where the power cord connects. To avoid electric shock with potential for severe injury or death, do not touch these areas when the power cord is plugged in.

WARNING: Unplug the AC power cord before opening pump housing to avoid risk of electric shock, which could result in death or serious injury.

CAUTION: Disconnect the battery connection P104 on I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the *On/Off* key twice to discharge the circuitry.

CAUTION: Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.

12V DC check - battery

Using the battery cable, connect a DC power supply to P104 on the I/O board. Adjust the power supply voltage to 12.5V. Turn the pump on and verify that the voltage between the cathode of D11 and TP7 (ground) (TP6 on Dosing boards) is 11.80V ± 0.30V.

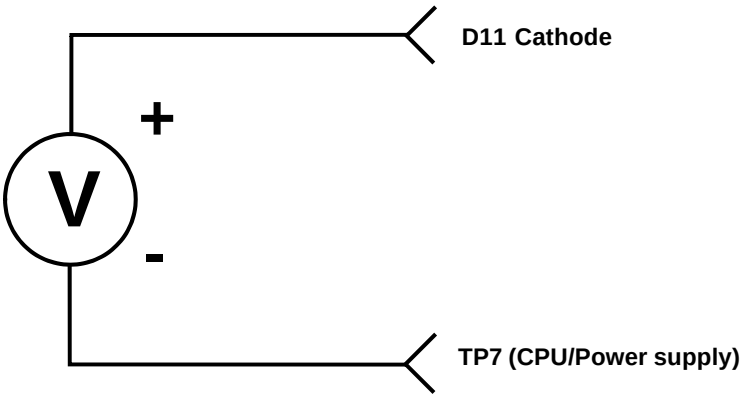


Figure 8.11 12V DC check.
12.5V DC applied to battery leads and pump turned on

13.8V DC check - power cord connected

Disconnect the pump from the AC power and disconnect the battery cable from P104 on the I/O board. Connect a Digital Voltmeter (DVM) to TP1 (TP2 on Dosing boards) and TP7 (ground) (TP6 on Dosing boards) on CPU/Power supply board. Plug the pump into the AC power. Turn the pump on and verify 13.8V ± 2V.

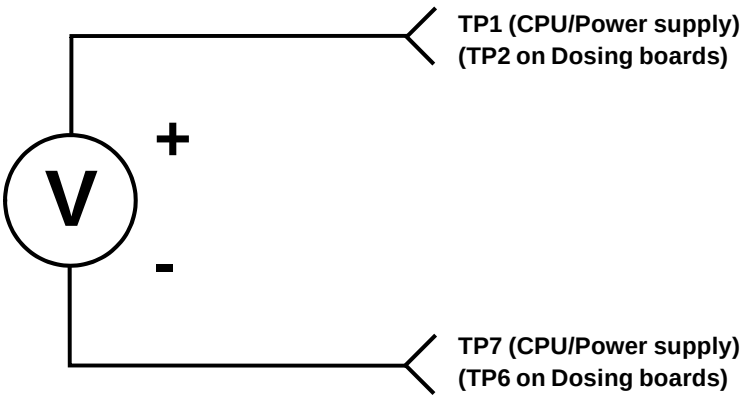


Figure 8.12 13.8V DC check.
Power cord plugged into AC and pump turned on

5.0V DC check - power cord connected

The front housing must be removed to verify the 5.0V DC voltage. Unplug the AC power cord and remove front housing. Disconnect the battery wire assembly from P104 on the I/O board. Connect a DC voltmeter to TP3 (TP1 on Dosing boards) and ground (TP7) (TP6 on Dosing boards). Plug in the AC power cord and turn the pump on. Verify a level of 5.1V ± 0.10V. Turn pump off.

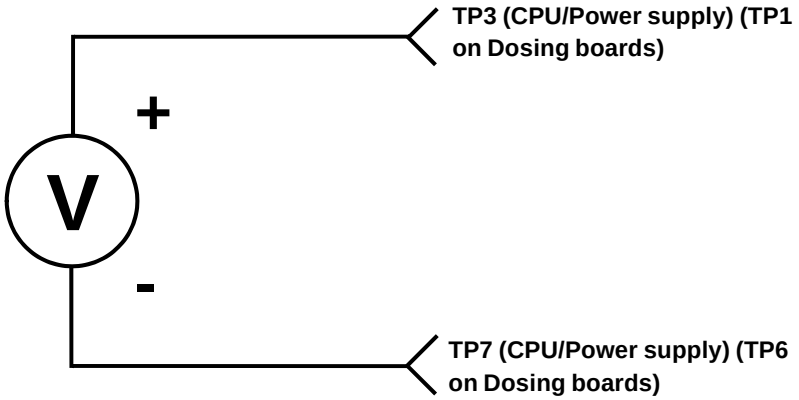


Figure 8.13 5.0V DC check.
Power cord plugged into AC and pump turned on

WARNING: Potentially dangerous voltages are exposed when the pump housing is open and the AC power cord is plugged in. These voltages are present in the transformer and AC fuse on the CPU/Power supply board and the RFI line filter where the power cord connects. To avoid electric shock with potential for severe injury or death, do not touch these areas when the power cord is plugged in.

WARNING: Unplug the AC power cord before opening pump housing to avoid risk of electric shock, which could result in death or serious injury.

CAUTION: Disconnect the battery connection P104 on I/O board before disassembling the circuit boards to avoid circuit damage. After disconnecting P104, press the *On/Off* key twice to discharge the circuitry.

CAUTION: Handling of printed circuit boards is required during disassembly/assembly. A static controlled work station including a conductive mat and grounded wrist strap should be used to provide protection against electrostatic discharge (ESD) or circuit board damage could result.

Low and dead battery alarm check

Low battery alarm

The battery voltage is monitored by an A/D converter (U408) and the Display control unit (U402) on the Display board. If the pump is operating under battery power and the voltage falls below 11.45V, the Display control unit signals to CPU1 and a low battery alarm is activated. The low battery trip point may be verified without opening the pump housing.

Unplug the AC power cord. Open the battery door and disconnect the battery terminals. This diagram illustrates the test setup:

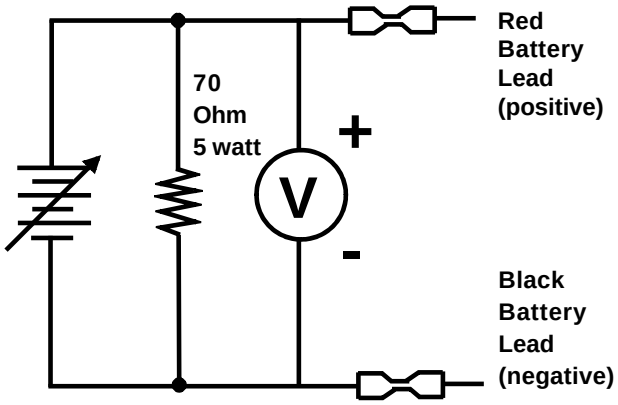


Figure 8.12 Low battery alarm verification set-up.

Connect both the DC power supply and the voltmeter across the battery leads (the red lead is positive and the black lead is ground potential).

Apply 12.5V to the battery leads and turn the pump on. Load the pump with a fluid filled cassette and enter a rate of 125 mL/h (99.9 mL/h on **3100/505**). Press ***Run*** and slowly decrease the DC voltage supplied while the pump is operating. Verify activation of the low battery alarm ('Low battery/plug in cord' in the Message display and non-insistent audio alarm sounding) when voltage reaches 11.45V ± 0.45V.

Dead battery alarm

The pumps will continue to operate at the selected rate following a low battery alarm. ***Silence*** is pressed to silence the non-insistent audio alarm. The battery indicator continues to flash if the pump remains in operation under battery power. A dead battery alarm is activated when the battery power drops below 11.0V (approximately 1/2 hour).

The dead battery alarm trip point may be verified following activation of initial low battery alarm. Press ***Silence*** to reset non-insistent audio alarm. Continue gradual reduction of DC power supply voltage. A dead battery alarm ('Battery too low/plug in cord' in the Message Display and an insistent audio alarm sounding) must activate at 10.8V ±0.4V.

Illustrated Parts List
Chapter 9

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

This section of the Illustrated Parts List lists only those parts which are available from Graseby Medical as spare parts for Volumetric Pumps with software/CPU version 0.71 and earlier with the old case design. These parts are clearly identified with an item number and part number, any item shown without a part number is for reference only and therefore not available as a spare part. The current price list for the Recommended Spare parts is available from Graseby Medical Limited (Customer Care).

The specification for the pumps may change with amended improvements and therefore the parts for the pumps may also change, without notice.

CAUTION **Because the circuit boards used in the pumps primarily consist of surface mounted technology, component level repair is not recommended.**

If you need parts for a Volumetric pump with a serial number from 60,000 see page 9-17.

Note: Software version 0.71 installed in old case design (serial numbers 3000 to 59,999) is only currently available for UK 500/505 and Deltec 3000/3100 pumps.

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

General assembly of the volumetric pump

Item	Description	Part number 3000/500	3100/505
1	Keypad Overlay		
	English, Finnish, Greek	0150-0157	0150-0158
	English - software version 0.71 only	0150-0633	0150-0634
	French	0150-0159	0150-0316
	Dutch	0150-0161	
	German	78-8095-2174-9	
	Italian	0150-0162	
	Portuguese	0150-0165	
	Deltec (USA)	0150-0168	0150-0169
	Swedish	0150-0166	0150-0167
	Spanish, Pan Spanish	0150-0160	
	Japan	78-8098-2291-5	
	Overlabels		
	When ordering a Keypad Overlay, also order an Overlabel if one is shown for your country in the list below:		
	English (UK only) - 500/505	0150-0250	0150-0251
	Finnish - 2 Labels required	0150-0318, 0150-0339	
	Greek	0150-0331	
	German	0150-0259	
	Italian	0150-0257	
	Spanish, Pan Spanish	0150-0256	
	Japan	0150-0252	
	Note: If no Overlabel is listed for your country, then no Overlabel is required.		
2	Door Front Assembly Kit		
	Kit contains: Keypad, Door - Front (For LED backlight LCD only) Keypad Overlay (English only), Lower Door Recess Label		
	software version 0.67 and earlier	0150-0501	0150-0502
	software version 0.71 only	0150-0811	0150-0812
3	Rear Door Assembly Kit	0150-0504	same
	Kit contains: Door - Rear LED, Handle Stop Assembly		
4	Top Hinge Bracket	78-8077-8237-6	same
5	Upper Hinge Bracket	78-8095-2516-1	same
6	Front Housing Assembly Kit	0150-0505	same
	Kit contains: Front Housing, *Warning Label - Free Flow (English only - see item 7 below), Gasket x 2, Foot Pad x 2		

Illustrated Parts List for pump Serial numbers from 3000 to 59.999

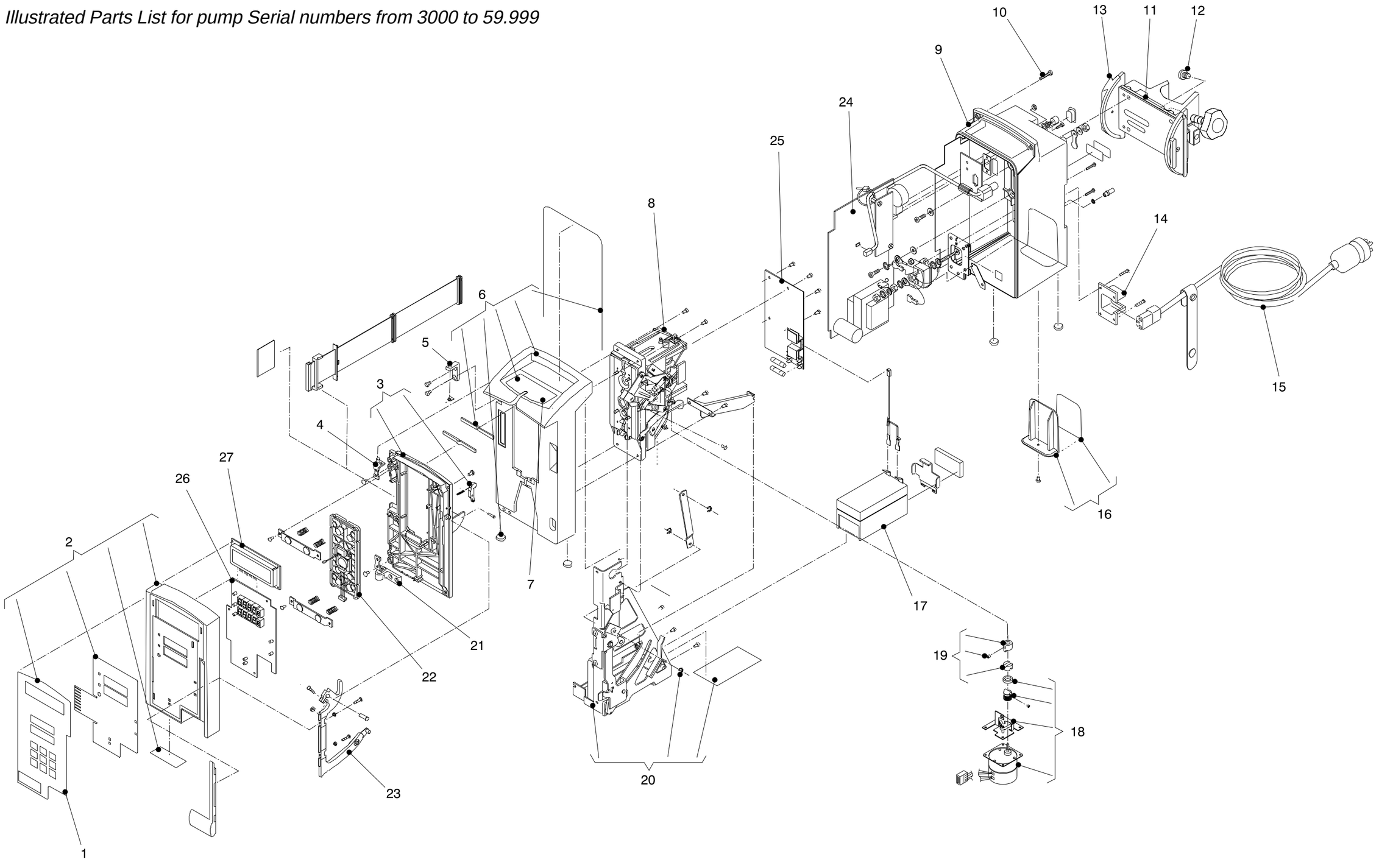


Figure 1 General Assembly of the Volumetric pump

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

Item	Description	Part number for all models
7	Warning Label, Free Flow	
	*For language variants of this label, order an item from this list:	
	English	78-8095-2647-4
	Dutch	78-8095-2655-7
	Japan	78-8095-2656-5
	French	78-8095-2657-3
	Italian	78-8095-2659-9
	German	78-8095-2661-5
	Spanish, Pan Spanish	78-8098-2901-9
	Swedish	0150-0292
	Portuguese	0150-0297
	Finnish	0150-0319
	Greek	0150-0330
	Deltec (USA)	0150-0343
8	Pump Assembly - *see Figure 2*	78-8092-5115-6
9	Rear Housing Assembly	*see Figure 3*
10	Case Screws - 3 off	5088-5510
11	Polesaver Kit	78-8098-2576-9
12	Pole Clamp Screw Pad	78-8098-2890-4
13	Polesaver Side Rail Kit	0150-0815
	Kit contains LH side rail, RH side rail, 2 Screws	
14	Universal power cord cover	78-8095-2507-0
15	Power Cord/Strap Assembly	
	120V - USA, Pan Spanish,	78-8092-5142-0
	120V - Japan, Canadian/French	78-8092-5142-0
	240V - Australian	78-8095-2485-9
	240V - English UK, English Outside UK	78-8095-2486-7
	220V - Dutch, French, Spanish, Italian	78-8098-2208-9
	220V - German, English European, Portuguese	78-8098-2208-9
	220V - Swedish, Finnish, Greek	78-8098-2208-9
16	Battery Door Assembly Kit	0150-0506
	Kit contains: Battery Door, Equipotential Label (Universal), 1 Screw	
17	Battery LCR - 12V,1.3Ah/20HR	78-8098-2277-4

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

Item	Description	Part number 3000/500	3100/505
18	Motor/Swing Arm Assembly	78-8095-2153-3	same
19	Coupler Assembly Kit	0150-0508	same
	Kit contains: Interface Coupler, Set Screw (4-40 UNC x 1/8"), Hub Coupler		
20	Frame Assembly Kit	0150-0507	same
	Kit contains: Frame Assembly, E-ring 3/16 - Spring Steel, Battery Label		
21	Lower Hinge Assembly	78-8095-2120-2	same
22	Pressure Plate Assembly	0150-0029	same
23	Inner Arm Assembly	78-8098-2216-2	same
24	CPU Power Supply/RS232 Board Assembly Dosing	*See Figure 5*	
25	I/O Board Assembly - *see Figure 6*	0150-0014	same
26	Display Board	*See Figure 4*	
27	Display Conversion Kit	0150-0503	0150-0522
	Kit contains the following parts: LCD Display (LED backlit)		
	Door Front Assembly, Door Rear Assembly, Instruction sheet		
	Note: If a replacement LCD is required and the Display Board is fitted with inverter U401, then the Display Board must be modified and the Display Conversion Kit should be ordered. See Chapter 7, *Troubleshooting* section.		
28	Kapton Tape - 1.5 inches wide	26-1011-7945-0	same
29	Instruction Manual - version 0.67 software or earlier		
	English UK 500/505	0150-0035	same
	English 3000/3100	0150-0039	same
	Pan Spanish	0150-0043	same
	French	0150-0221	same
	Dutch	0150-0222	same
	Spanish	0150-0223	same
	German	0150-0224	same
	Portuguese	0150-0225	same
	Italian	0150-0226	same
	Swedish	0150-0227	same
	Deltec - USA	0150-0229	same
	USA	0150-0037	same
	Finnish	0150-0317	same
	Greek	0150-0338	same

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

Item	Description	Part number 3000/500	3100/505
30	Instruction Manual - version 0.71 software only		
	English UK 500/505	0150-0652	same
	Deltec 3000/3100	0150-0218	same
31	Technical User Manual - version 0.71 software only		
	English UK 500/505	0150-0653	same
	Deltec 3000/3100	0150-0219	same
32	Service Manual	0166-0250	same
33	Software Upgrade Kit to version 0.71 software	0150-0671	0150-0672
34	History Download Software Kit	0150-0673	same
35	Service Tool Kit	78-8061-4214-3	same

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

Pump assembly

Item	Description	Part number for all models
	Pump Assembly	78-8092-5115-6
1	Snap Switch - 2 off	26-1006-5104-6
2	Optical Emitter PCB Assembly	0150-0018
3	Optical Detector PCB Assembly	0150-0020

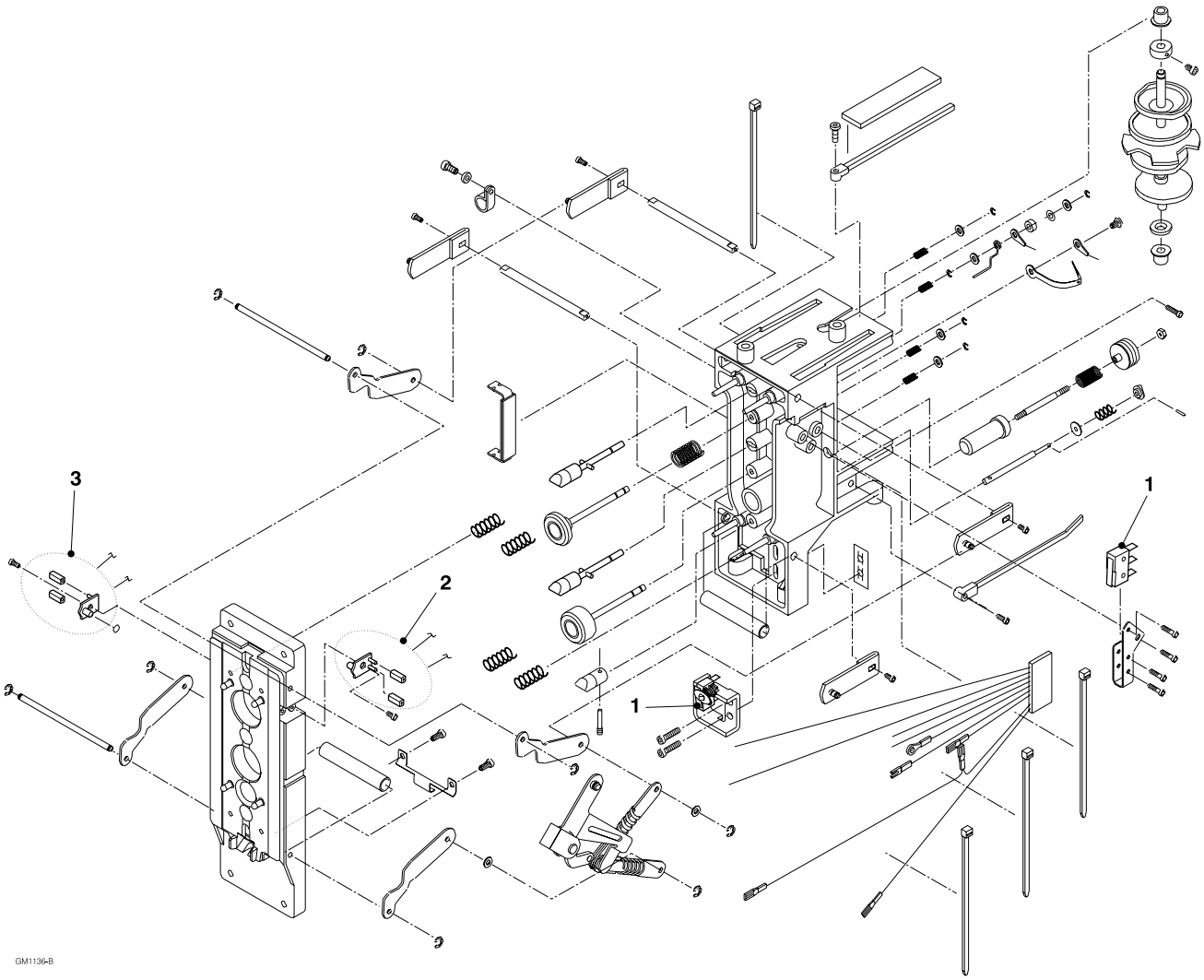


Figure 2 Pump assembly

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

Rear housing assembly

Item	Description	Part number for all models
1	Rear Housing	
	CE Marked Pumps - without NCO	78-8098-2736-9
	CE Marked Pumps - with NCO	78-8098-2751-8
	Non CE Marked Pumps - without NCO	78-8095-3050-0
	Non CE Marked Pumps - with NCO	78-8095-2777-9
	Note: The Serial Number Label should be carefully removed from the original housing and re-used on the new Rear Housing. The Battery Door is a separate part, not included with the Rear Housing.	
	Note: When ordering a new Rear Housing, also order a label from the list below to ensure correct labelling and traceability. It is the responsibility of the "pump's owner" to ensure that the correct labels are replaced on the pump.	
2	Caution Label	
	English	NA
	USA	0150-0344
	French, Canadian French	78-8095-2238-2
	German	78-8095-2239-0
	Italian	78-8095-2240-8
	Dutch	78-8095-2242-4
	Spanish, Pan Spanish	78-8098-2224-6
	Swedish	0150-0298
	Japan	78-8095-2244-0
	Portuguese	0150-0291
	Finnish	0150-0320
	Greek	0150-0332
3	Orientation Label	78-8095-2891-8
4	Polesaver Label	
	English	78-8098-2420-0
	USA	0150-0342
	French, Canadian French	78-8098-2491-1
	German	78-8098-2490-3
	Italian	78-8098-2492-9
	Dutch	78-8098-2493-7
	Spanish, Pan Spanish	78-8098-2496-0
	Swedish	0150-0303

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

Item	Description	Part number All models
	Japan	78-8098-2495-2
	Portuguese	0150-0302
	Finnish	0150-0321
	Greek	0150-0333
5	**Jack Panel Label**	78-8095-2642-5
6	Ratings Label	
	When ordering a CE marked Ratings Label, please supply the serial number details of the Volumetric Pump. If this information is not supplied then a Non CE Marked Label will be issued.	
	It is the responsibility of the owner to ensure that the correct labels are replaced on the Volumetric Pump.	
	CE Marked 220-240V	
	English UK, English European,	
	French, German, Italian, Spanish	0150-0093
	CE Marked 220V NCO -	
	French, Dutch, German (Non Dosing)	0150-0094
	CE Marked 220V NCO - Portuguese	0150-0294
	CE Marked 220V NCO - Swedish	0150-0295
	CE Marked 220V - Finnish	0150-0322
	CE Marked 220V - Greek	0150-0334
	120V NCO - Deltec (USA)	0150-0625
	120V - Deltec (USA)	0150-0092
	220V - English Outside UK, Pan Spanish	0150-0095
	240V - Australia/New Zealand	0150-0096
	100V - Japan	0150-0097
	120V - USA, Canadian/French, Pan Spanish	0150-0098
7	Start-up Label - for versions 0.67 software	
	English	78-8098-2818-5
	French, French Canadian	0150-0083
	German	0150-0089
	Italian	0150-0088
	Dutch	0150-0084
	Spanish, Pan Spanish	0150-0079
	Swedish	0150-0086

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

Item	Description	Part number All models
	Japan	0150-0082
	Portuguese	0150-0085
	Finnish	0150-0324
	Greek	0150-0336
	Deltec (USA)	0150-0313
	Start-up Label - for versions 0.71 software	
	English, Deltec	0150-0566
8	Fuse Label	0150-0093
9	Tracking Label - Deltec (USA)	0150-0345
10	Rear Housing Assembly Kit (English only)	0150-0509
	Non CE Marked Non Dosing Models - Kit contains: Rear Housing, Orientation Label, Polesaver Label, Jack Panel Label, Non CE Marked Ratings Label, Non Dosing Start-up Label, Fuse Label, Foot Pad x 2	

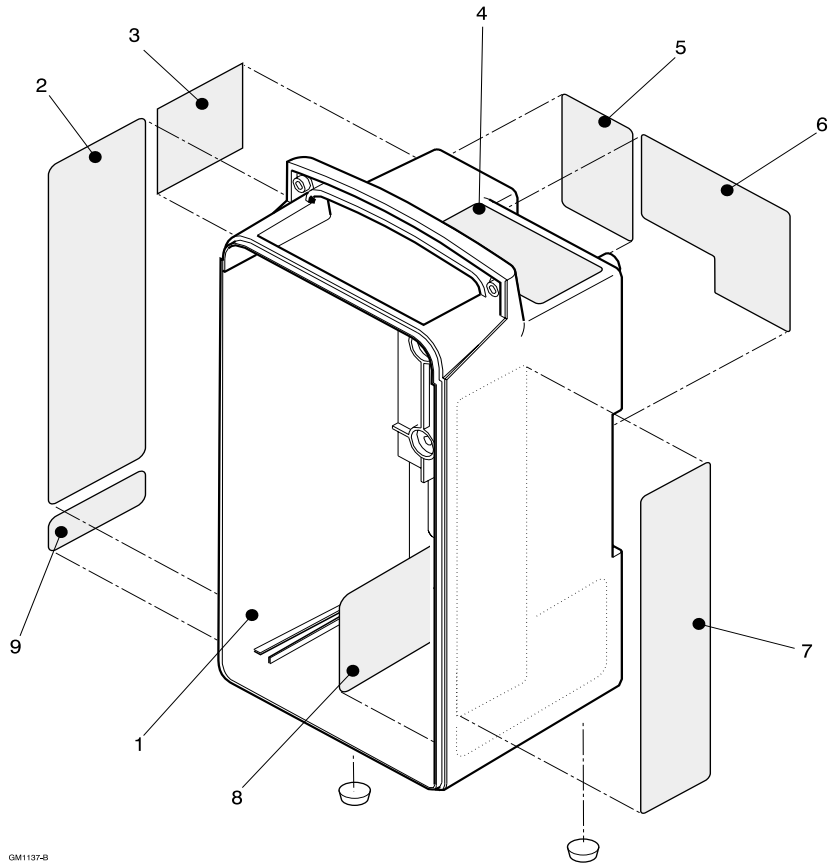


Figure 3 Rear housing assembly - labels

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

Display board assembly

Item	Description	Part number All models
	Display Board Assembly	
	Non Dosing - Spanish, Pan Spanish	0150-0137
	Non Dosing - Dutch	0150-0138
	Non Dosing - Italian	0150-0139
	Non Dosing - German	0150-0141
	Non Dosing - English	0150-0143
	Dosing 0.67 software - English outside UK	0150-0135
	Dosing 0.67 software - Japan	0150-0140
	Dosing 0.67 software - UK, USA, European English Australian, Finnish, Greek	0150-0149
	Dosing 0.67 software - French, Canadian French	0150-0230
	Dosing 0.67 software - Dutch	0150-0231
	Dosing 0.67 software - Spanish	0150-0233
	Dosing 0.67 software - Italian	0150-0234
	Dosing 0.67 software - German	0150-0235
	Dosing 0.67 software - Swedish	0150-0236
	Dosing 0.67 software - Portuguese	0150-0237
	Dosing 0.71 software - UK (500/505 only)	0150-0656
1	U401, IC EL Backlight	78-8095-2263-3
2	U402, CPU3 Memory Assembly	78-8095-2892-6
	Non Dosing - Spanish, Pan Spanish	78-8095-2558-3
	Non Dosing - Dutch	78-8095-2473-5
	Non Dosing - Italian	78-8095-2557-5
	Non Dosing - German	78-8095-2559-1
	Non Dosing - English	78-8092-5123-0
	Dosing 0.67 software - English outside UK	78-8095-2892-6
	Dosing 0.67 software - Japan	78-8098-2384-8
	Dosing 0.67 software - UK, USA, European English Australian, Finnish, Greek	0150-0145
	Dosing 0.67 software - French, Canadian French	0150-0210
	Dosing 0.67 software - Dutch	0150-0211
	Dosing 0.67 software - Spanish	0150-0213

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

Item	Description	Part number All models
	U402, CPU3 Memory Assembly (continued)	
	Dosing 0.67 software - Italian	0150-0214
	Dosing 0.67 software - German	0150-0215
	Dosing 0.67 software - Swedish	0150-0216
	Dosing 0.67 software - Portuguese	0150-0217
	Dosing 0.71 software - UK (500/505 only)	0150-0641

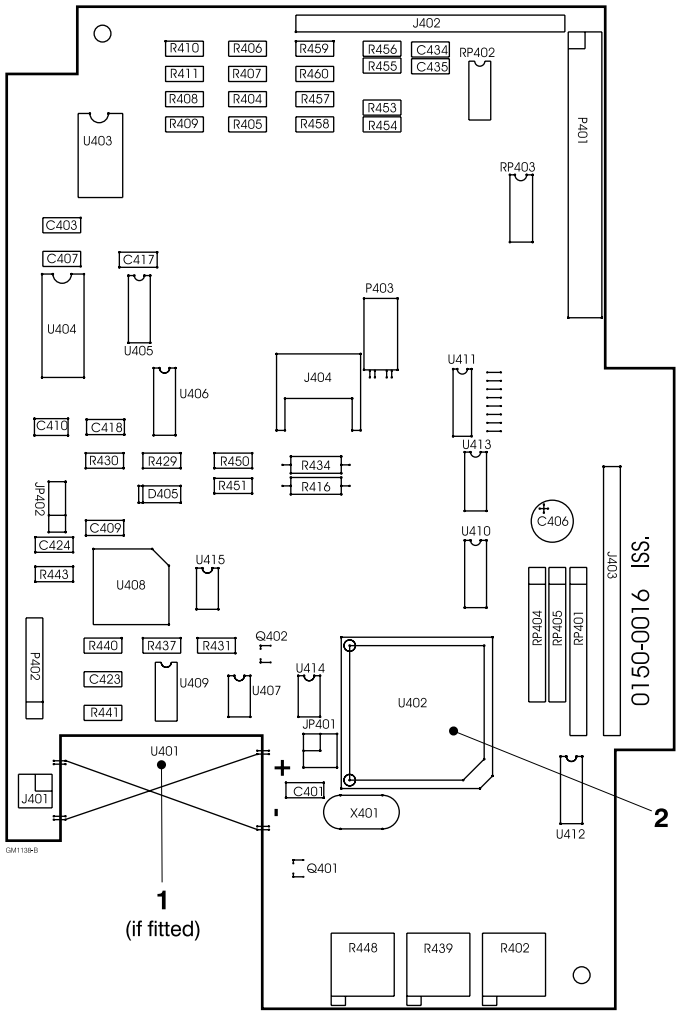


Figure 4 Display board assembly (side 2)

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

CPU power supply/RS232 board assembly

Item	Description	Part numbers for all models
CPU Power Supply/RS232 Board Assembly		
	500/3000 Dosing 0.67 software 230V	
	English, French, Italian, German, Spanish, Finnish, Greek	0150-0055
	3000 Dosing 0.67 software 230V NCO	
	Dutch, French, Portuguese, Swedish	0150-0066
	3100 Dosing 0.67 software 230V NCO - Swedish	0150-0067
	3000 Dosing 0.67 software 120V NCO - Deltec (USA), Pan Spanish	0150-0053
	3000 Dosing 0.67 software 220V - English outside UK	0150-0051
	3000 Dosing 0.67 software 120V - Canadian French	0150-0052
	3100 Dosing 0.67 software 120V - Deltec (USA), Canadian English	0150-0058
	3000 Dosing 0.65 software 100V - Japan	0150-0054
	505/3100 Dosing 0.67 software - English, French	0150-0060
	3000 Non Dosing 220V - English, Italian, Spanish, Pan Spanish	0150-0061
	3000 Non Dosing 220V NCO - German	0150-0063
	3000 Non Dosing 120V - Pan Spanish	0150-0064
	500 English Dosing 0.71 software 230V	0150-0654
	505 English Dosing 0.71 software 230V	0150-0655
1	Mains Fuse - 5 x 20 mm 80 MA 250 V (IEC)	26-1011-6223-3
2	Mains Transformer, T1 - BE25774-002	0150-0008
3	NV RAM Spares Kit:	
	28 Pin Version	0150-0549
	24 Pin Version	0150-0550
4	Audio Transducer	3380-1020
5	Potentiomenter	2092-3505
6	Push Button Switch	3500-0600

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

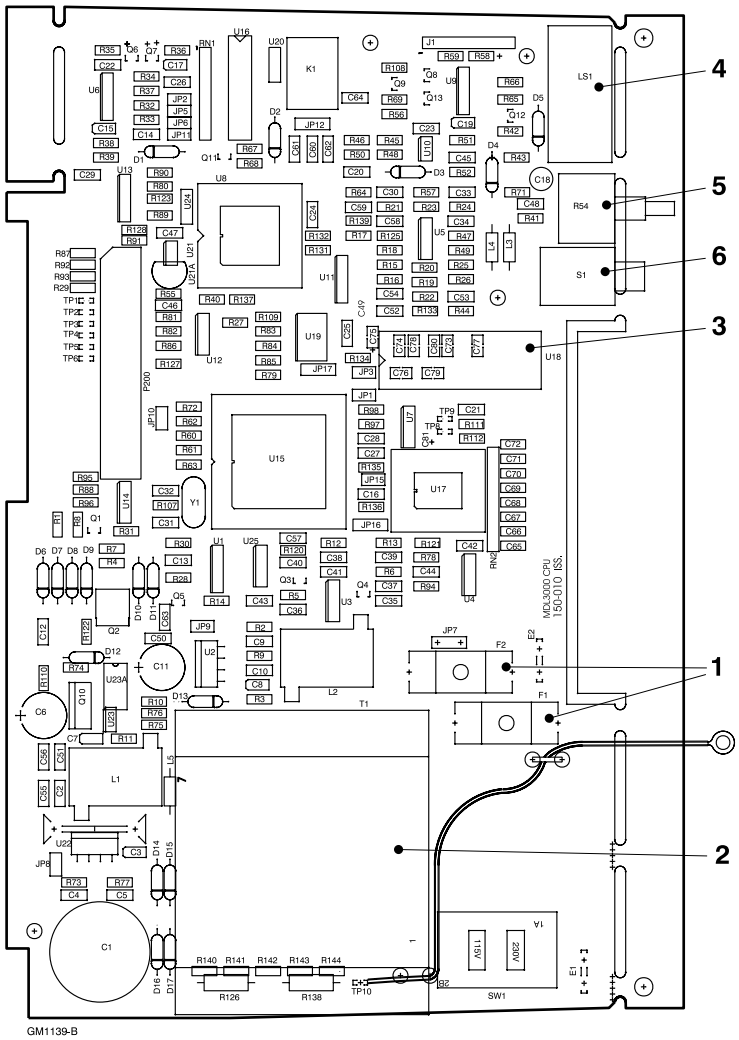


Figure 5 CPU power supply/RS232 board assembly

Illustrated Parts List for pump Serial numbers from 3000 to 59,999

I/O board assembly

Item	Description	Part number for all models
	I/O Board Assembly	0150-0014
1	Optical Sensor EE-SX1042 OMRON	3384-1000
2	Battery Fuse - T1A 5 x 20 - IEC	3410-3730

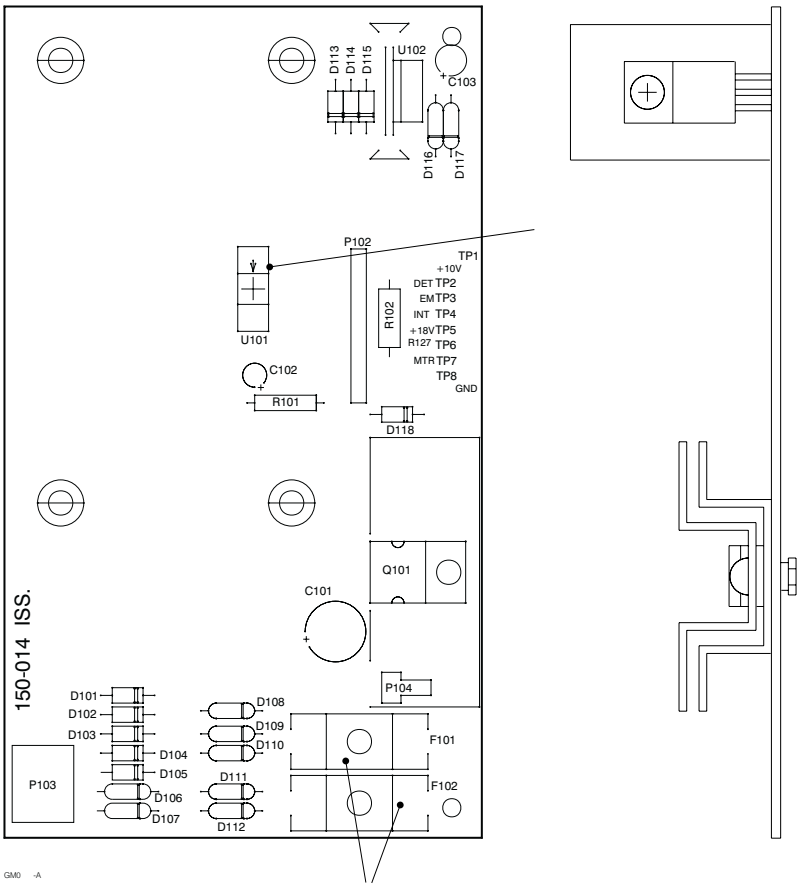


Figure 6 I/O board assembly

9

Illustrated Parts List for Serial numbers from 60,000

This section of the Illustrated Parts List lists only those parts which are available from Graseby Medical as spare parts for Volumetric Pumps with new case design and software version 0.71 and above. These parts are clearly identified with an item number and part number, any item shown without a part number is for reference only and therefore not available as a spare part. The current price list for the Recommended Spare parts is available from Graseby Medical Limited (Customer Care).

The specification for the pumps may change with amended improvements and therefore the parts for the pumps may also change, without notice.

CAUTION **Because the circuit boards used in the pumps primarily consist of surface mounted technology, component level repair is not recommended.**

If you need parts for a Volumetric pump with a serial number lower than 60,000, see page 9-1.

Illustrated Parts List for pump Serial numbers from 60,000 only

General assembly of the volumetric pump

Item	Description	Part number 3000/500	3100/505
1	Overlay Kit		
	Kit contains: Keypad Overlay, Display Window		
	UK 500/505,	0166-0270	0166-0271
	English 3000/3100	0166-0272	0166-0273
	Deltec (USA)	0166-0274	0166-0275
2	Door Front Assembly Kit	0166-0252	0166-0253
	Kit contains: Keypad, Door - Front (For LED backlight LCD only) Keypad Overlay (English only), Lower Door Recess Label, Display screen		
3	Rear Door Assembly Kit	0166-0254	same
	Kit contains: Door - Rear LED, Handle Stop Assembly		
4	Top Hinge Bracket	78-8077-8237-6	same
5	Upper Hinge Bracket	78-8095-2516-1	same
6	Front Housing Assembly Kit	0166-0255	same
	Kit contains: Front Housing, *Warning Label - Free Flow (English only - see item 7 below), Gasket x 2, Foot Pad x 2		
7	Warning Label, Free Flow		
	*For language variants of this label, order an item from this list:		
	English, Deltec (USA)	0166-0063	same
8	Pump Assembly - *see Figure 8*	78-8092-5115-6	same
9	Rear Housing Assembly	*see Figure 9*	
10	Case Screws - 3 off	5088-5510	same
11	Polesaver Kit	0166-0251	same
12	Pole Clamp Screw Pad	78-8098-2890-4	same
13	Polesaver Side Rail Kit	0166-0258	same
	Kit contains LH side rail, RH side rail, 2 Screws		
14	Universal power cord cover	78-8095-2507-0	same
15	Power Cord/Strap Assembly		
	120V - USA,	78-8092-5142-0	same
	240V - English UK, English Outside UK	78-8095-2486-7	same
	220V - English European,	78-8098-2208-9	same
16	Battery Door Assembly Kit	0166-0256	same
	Kit contains: Battery Door, Equipotential Label (Universal), 1 Screw		
17	Battery LCR - 12V,1.3Ah/20HR	78-8098-2277-4	same
18	Motor/Swing Arm Assembly	78-8095-2153-3	same
19	Coupler Assembly Kit	0150-0508	same
	Kit contains: Interface Coupler, Set Screw (4-40 UNC x 1/8"), Hub Coupler		

Illustrated Parts List for pump Serial numbers from 60,000 only

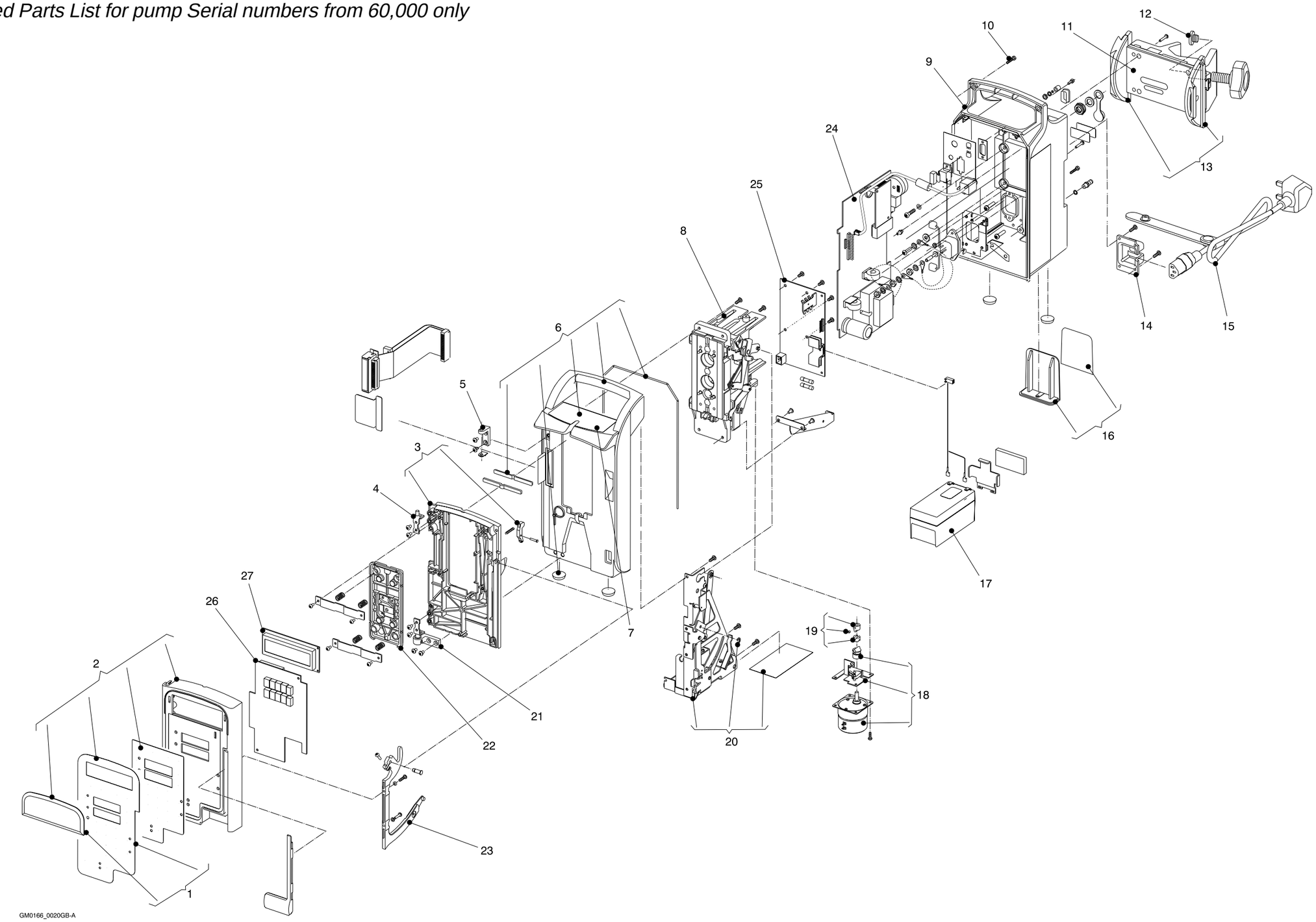


Figure 7 General Assembly of the Volumetric pump

Illustrated Parts List for pump Serial numbers from 60,000 only

Item	Description	Part number 3000/500	3100/505
20	Frame Assembly Kit Kit contains: Frame Assembly, E-ring 3/16 - Spring Steel, Battery Label	0150-0507	same
21	Lower Hinge Assembly	78-8095-2120-2	same
22	Pressure Plate Assembly	0150-0029	same
23	Inner Arm Assembly	78-8098-2216-2	same
24	CPU Power Supply/RS232 Board Assembly Dosing	*See Figure 11*	
25	I/O Board Assembly - *see Figure 12*	0150-0014	same
26	Display Board	*See Figure 10*	
27	LCD display	0150-0810	same
28	Kapton Tape - 1.5 inches wide	26-1011-7945-0	same
29	Instruction Manual - 0.71 software or later		
	English UK, Canada 500/505	0166-0027	same
	English 3000/3100 Version	0166-0028	same
	Deltec (USA)	0166-0039	same
30	Technical User Manual - 0.71 software or later		
	English UK, Canada 500/505	0166-0202	same
	English 3000/3100	0166-0203	same
	Deltec (USA)	0166-0214	same
31	Service Manual	0166-0250	same
32	History Download Software Kit	0150-0673	same
33	Service Tool Kit	78-8061-4214-3	same

Illustrated Parts List for pump Serial numbers from 60,000 only

Pump assembly

Item	Description	Part numbers for all models
	Pump Assembly	78-8092-5115-6
1	Snap Switch - 2 off	26-1006-5104-6
2	Optical Emitter PCB Assembly	0150-0018
3	Optical Detector PCB Assembly	0150-0020

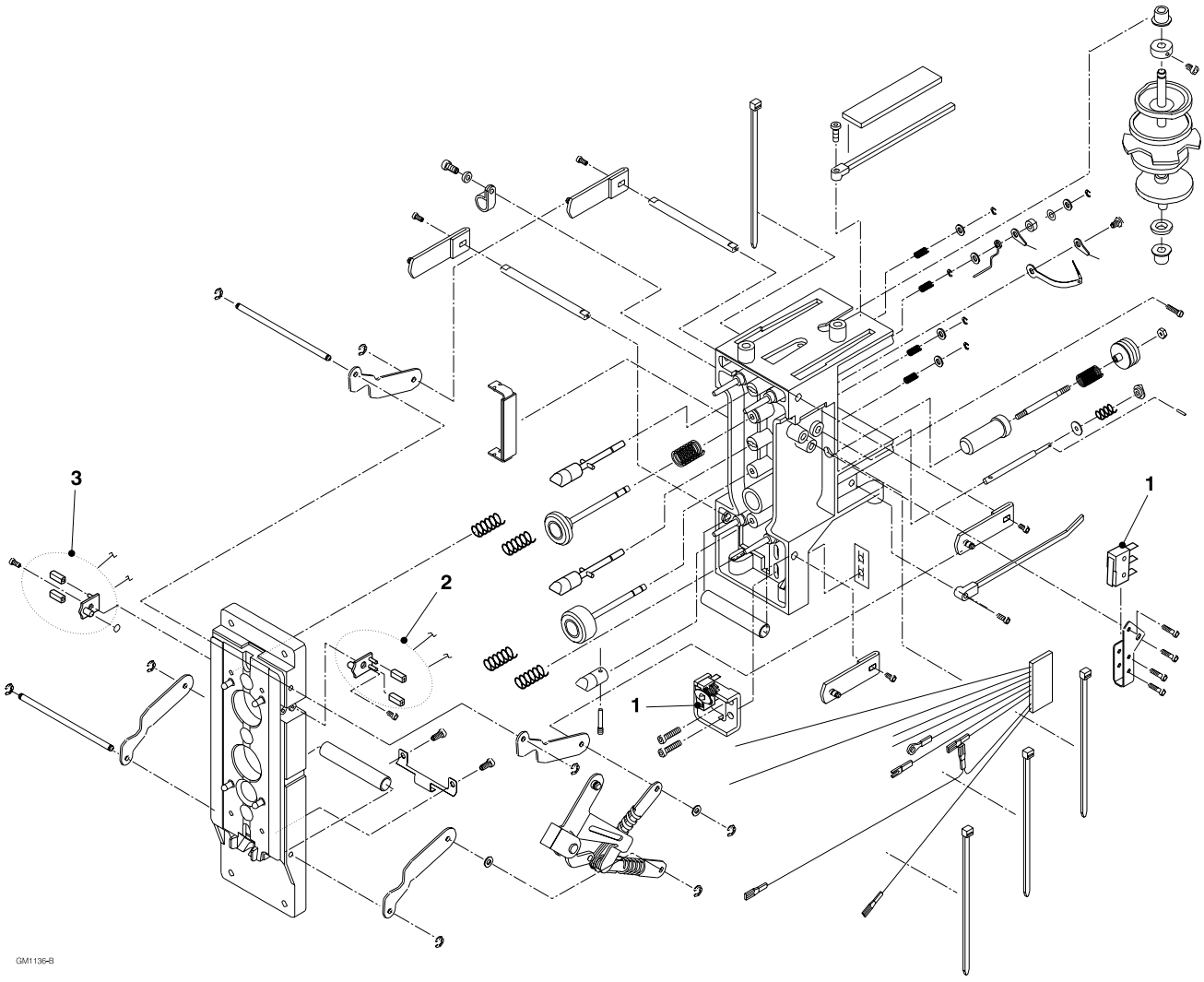


Figure 8 Pump assembly

Illustrated Parts List for pump Serial numbers from 60,000 only

Rear housing assembly

Item	Description	Part number for all models
1	Rear Housing - CE Marked standard	
	Rear Housing without NCO	0166-0297
	Rear Housing with NCO	0166-0298
	Note: The Serial Number Label should be carefully removed from the original housing and re-used on the new Rear Housing. The Battery Door is a separate part, not included with the Rear Housing.	
	Note: When ordering a new Rear Housing, also order a label from the list below to ensure correct labelling and traceability. It is the responsibility of the "pump's owner" to ensure that the correct labels are replaced on the pump.	
2	Caution Label	
	English	0166-0079
	Deltec (USA)	0166-0092
3	Orientation Label	0166-0127
4	Polesaver Label	
	English, Deltec (USA)	0166-0111
5	Jack Panel Label	78-8095-2642-5
6	Ratings Label When ordering a CE marked Ratings Label, please supply the serial number details of the Volumetric Pump. If this information is not supplied then a Non CE Marked Label will be issued. It is the responsibility of the owner to ensure that the correct labels are replaced on the Volumetric Pump.	
	CE Marked 220-240V -	
	English UK, English European	0166-0048
	120V NCO - Deltec (USA)	0166-0054
	120V - Deltec (USA)	0166-0053
	220V - English Outside UK	0166-0046
7	Start-up Label - English, Deltec (USA)	0166-0095
8	Fuse Label	0166-0128
9	Tracking Label - Deltec (USA)	0150-0345

Illustrated Parts List for pump Serial numbers from 60,000 only

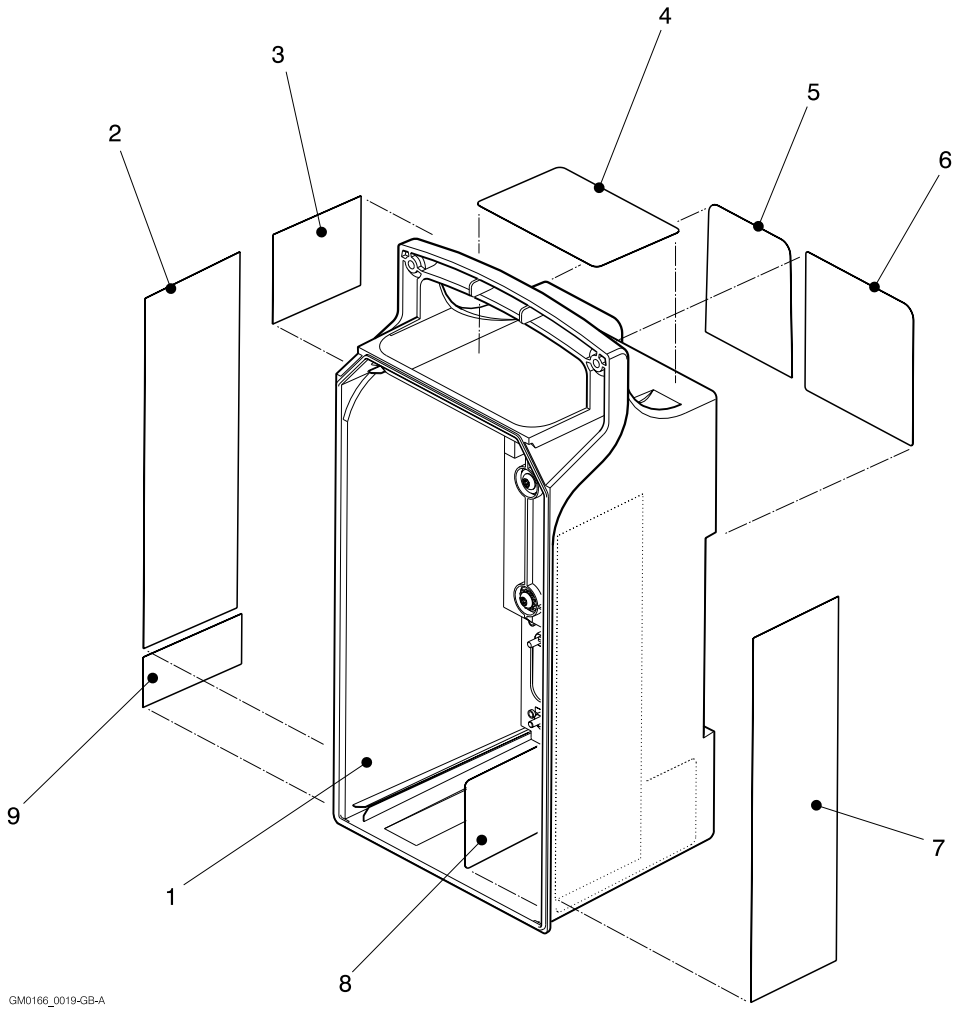


Figure 9 Rear housing assembly - labels

Illustrated Parts List for pump Serial numbers from 60,000 only

Display board assembly

Item	Description	Part number for all models
	Display Board Assembly	
	Dosing - All English variants	0150-0656
1	U402, CPU3 Memory Assembly	
	All English variants	0150-0641

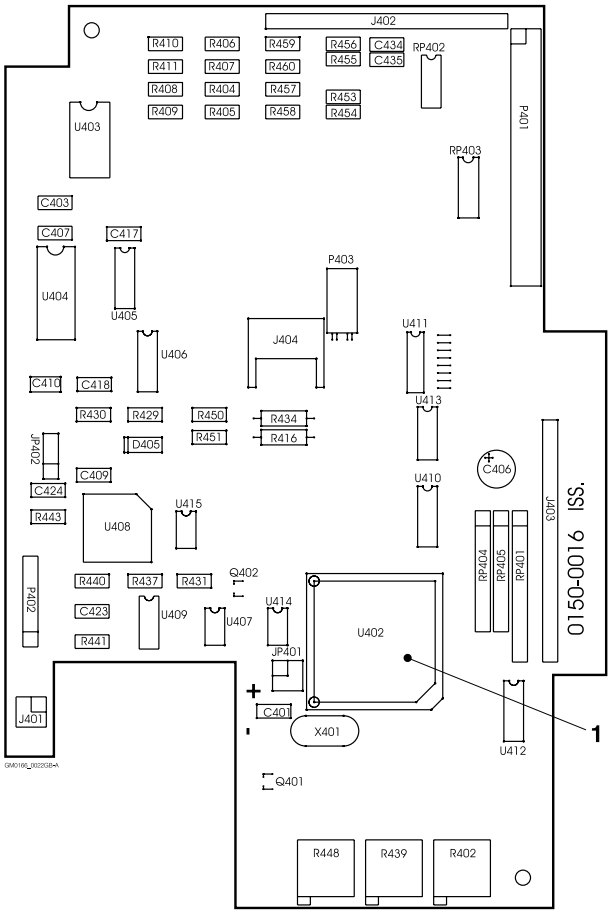


Figure 10 Display board assembly (side 2)

Illustrated Parts List for pump Serial numbers from 60,000 only

CPU power supply/RS232 board assembly

Item	Description	Part number for all models
	CPU Power Supply/RS232 Board Assembly	
	3000/500 Dosing 0.71 software 230V - English	0150-0654
	3000 Dosing 0.71 software 120V NCO - Deltec (USA)	0150-0804
	3100 Dosing 0.71 software 120V - Deltec (USA)	0150-0803
	3100/505 Dosing 0.71 software 230V - English,	0150-0655
1	Mains Fuse - 5 x 20 mm 80 MA 250 V (IEC)	261011-6223-3
2	Mains Transformer, T1 - BE25774-002	0150-0008
3	NV RAM Spares Kit - 28 Pin Version	0150-0549
4	Audio Transducer	3380-1020
5	Potentiomenter	2092-3505
6	Push Button Switch	3500-0600

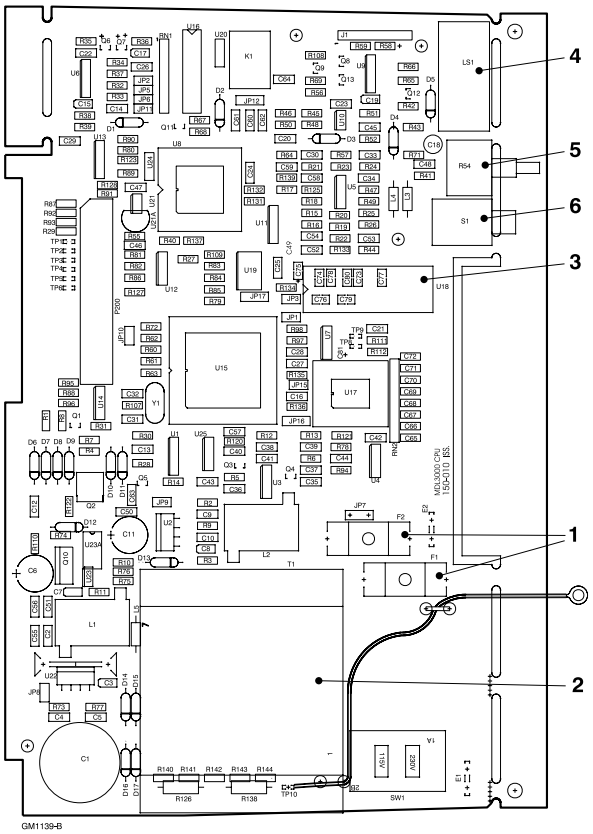


Figure 11 CPU power supply/RS232 board assembly

Illustrated Parts List for pump Serial numbers from 60,000 only

I/O board assembly

Item	Description	Part number for all models
	I/O Board Assembly	0150-0014
1	Optical Sensor EE-SX1042 OMRON	3384-1000
2	Battery Fuse - T1A 5 x 20 - IEC	3410-3730

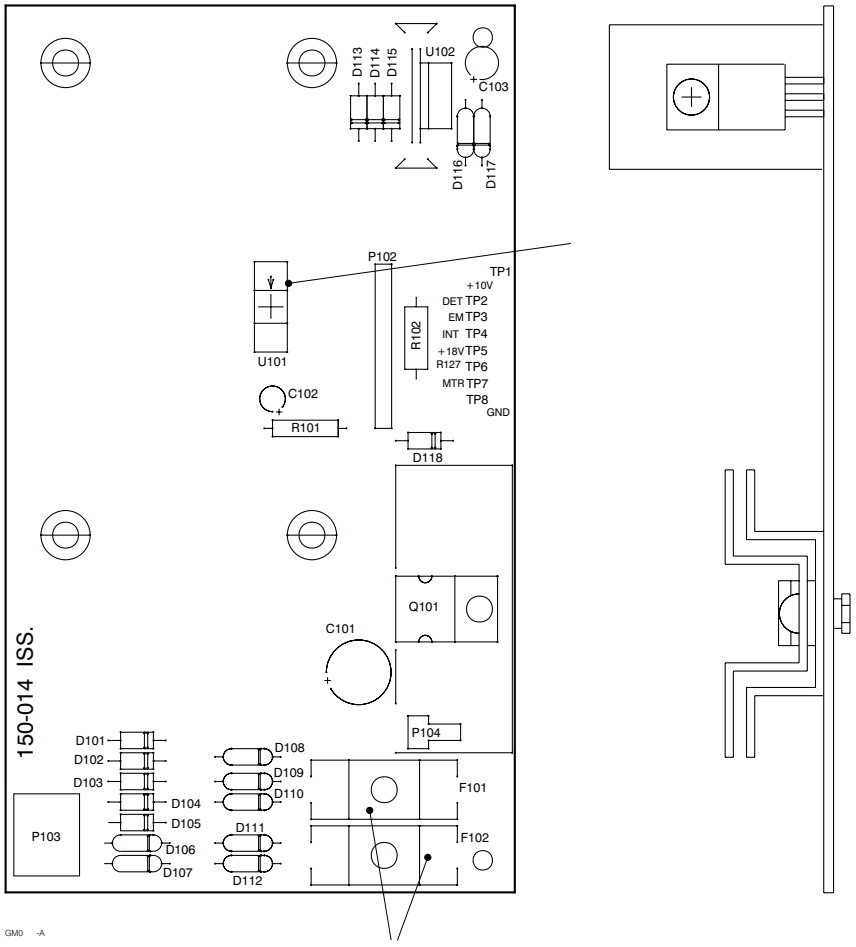
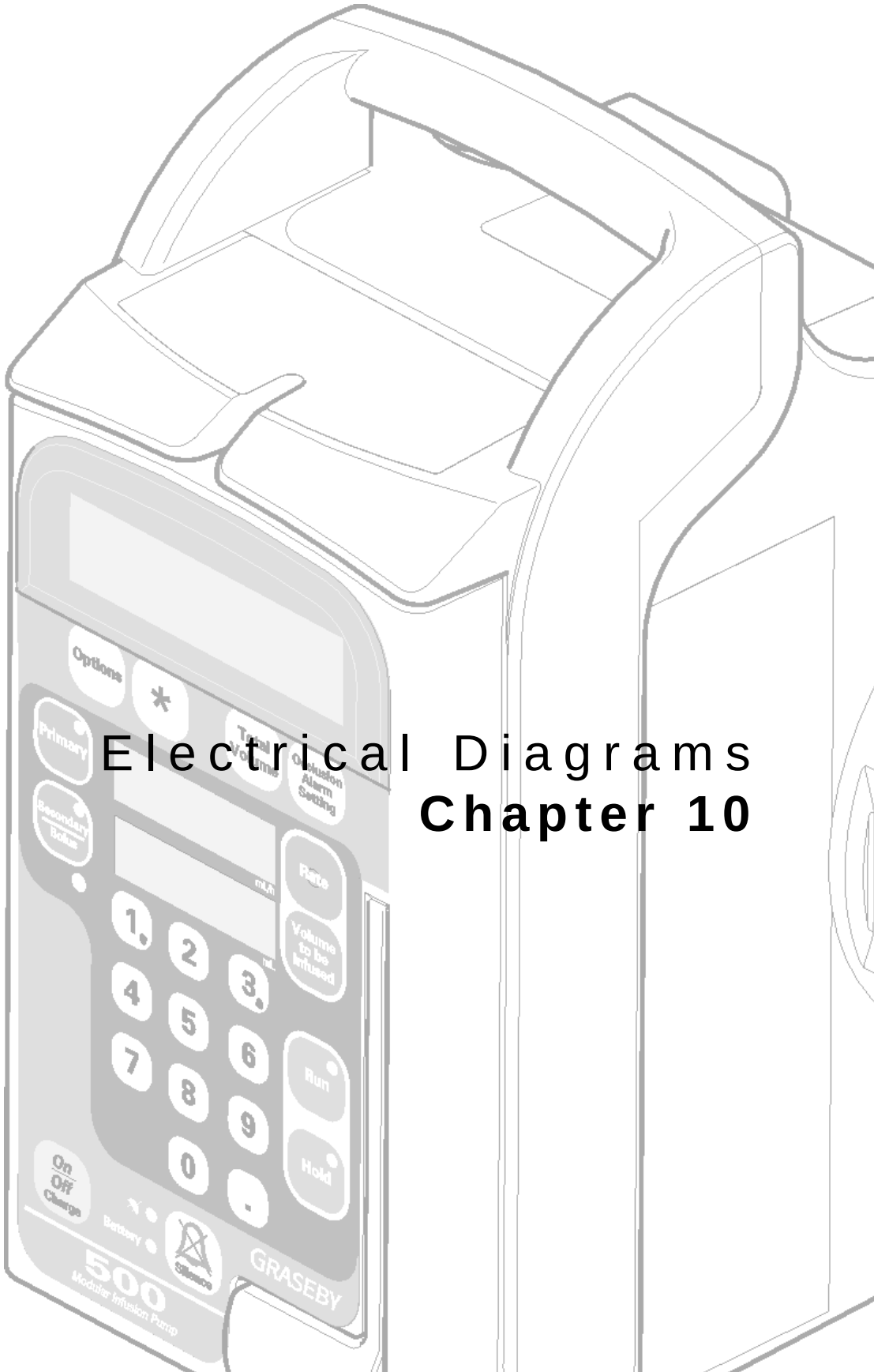


Figure 12 I/O board assembly



Electrical Diagrams
Chapter 10

Electrical Diagrams

Introduction

This chapter contains the following diagrams:

Page	Title
10-2	Figure 10-1 Overall functional block diagram
10-3	Figure 10-2 Power routeing block diagram
10-4	Figure 10-3 Electrical routeing block diagram
10-5	Figure 10-4 Display board schematic
10-6	Figure 10-5 CPU/Power supply schematic (sheet 1 of 3)
10-7	Figure 10-6 CPU/Power supply schematic - CE (sheet 2 of 3)
10-8	Figure 10-7 CPU/Power supply circuit (sheet 3 of 3)
10-9	Figure 10-8 Input/Output schematic
10-10	Figure 10-9 RS232 schematic

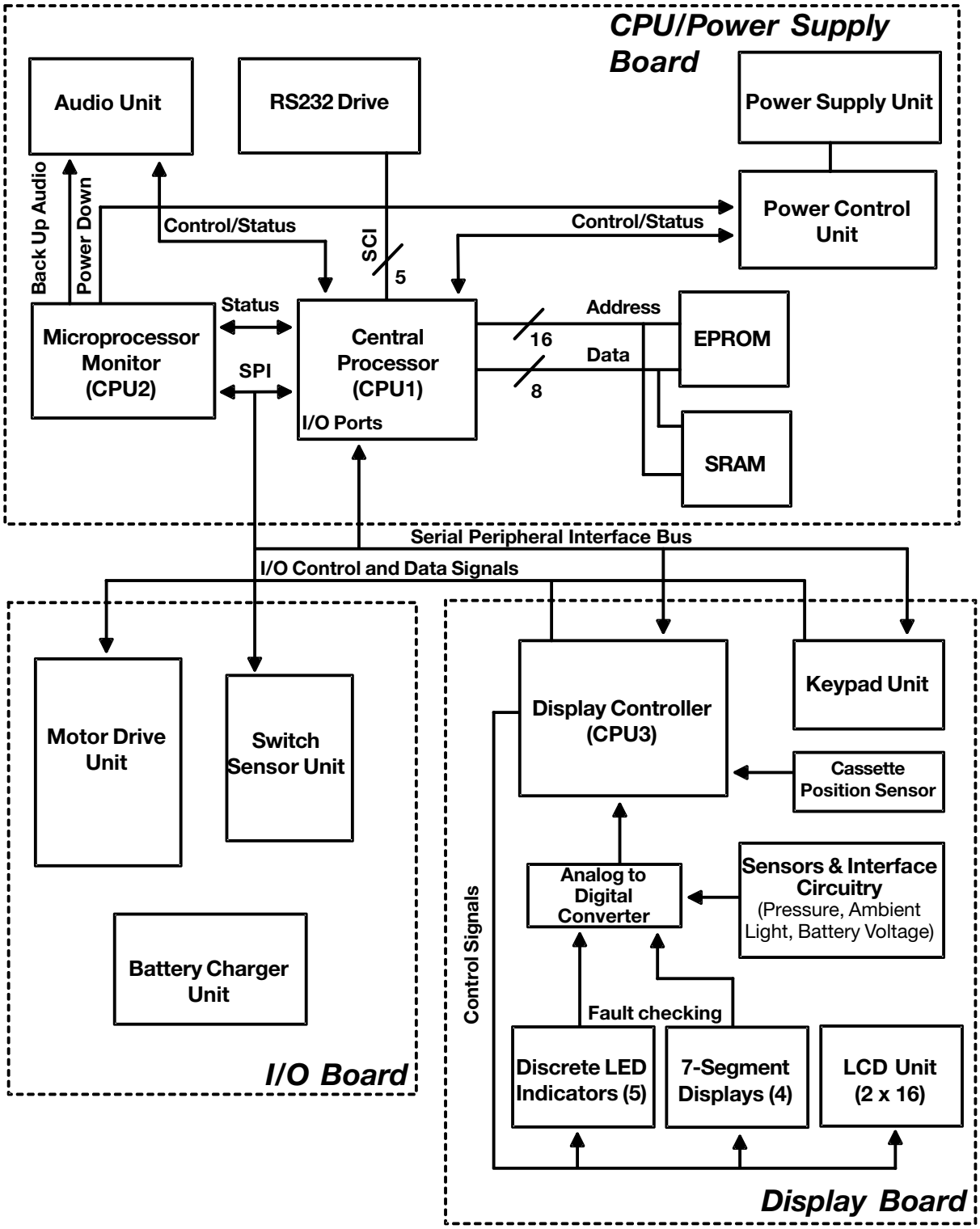


Figure 10-1 Overall functional block diagram

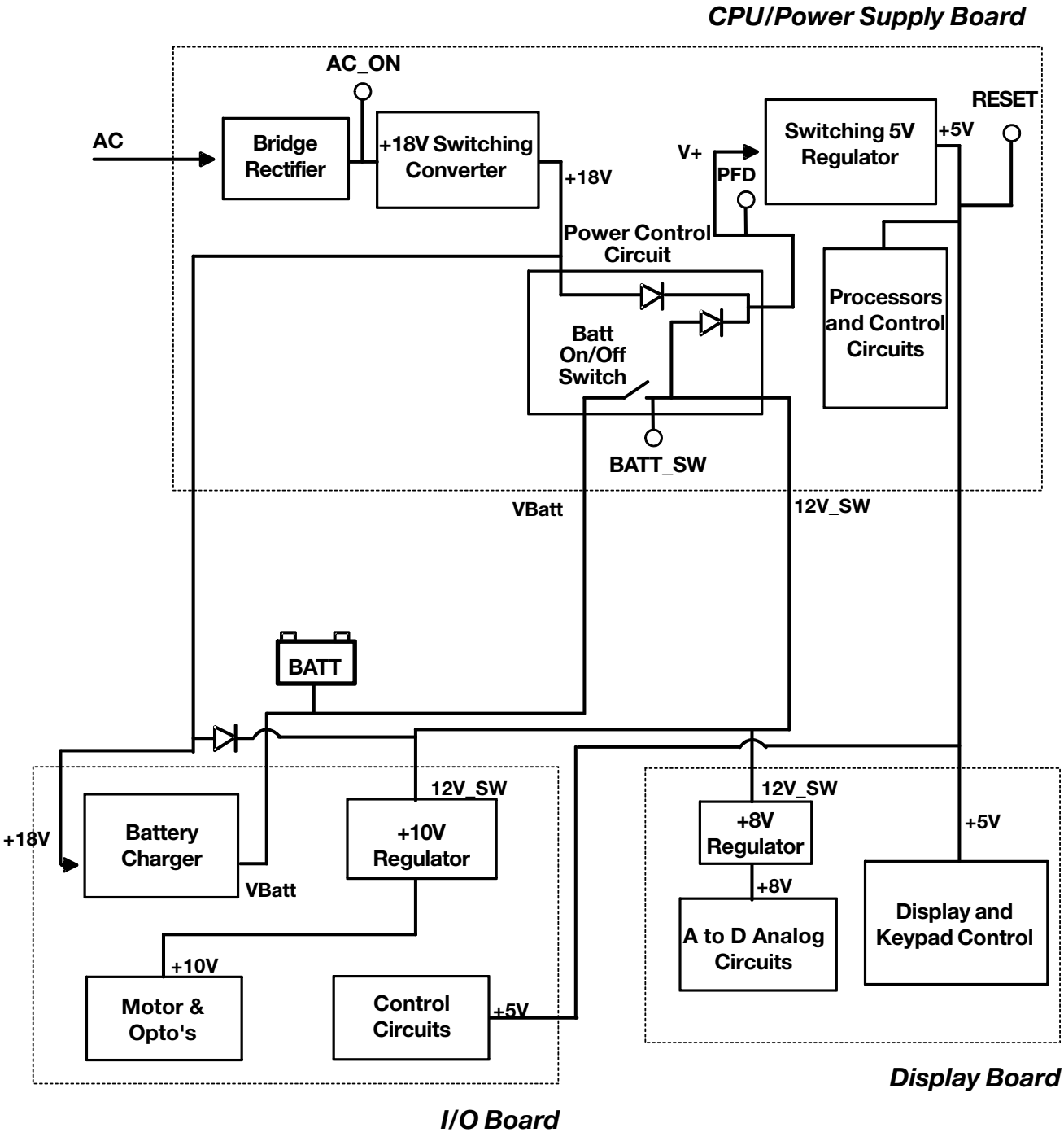
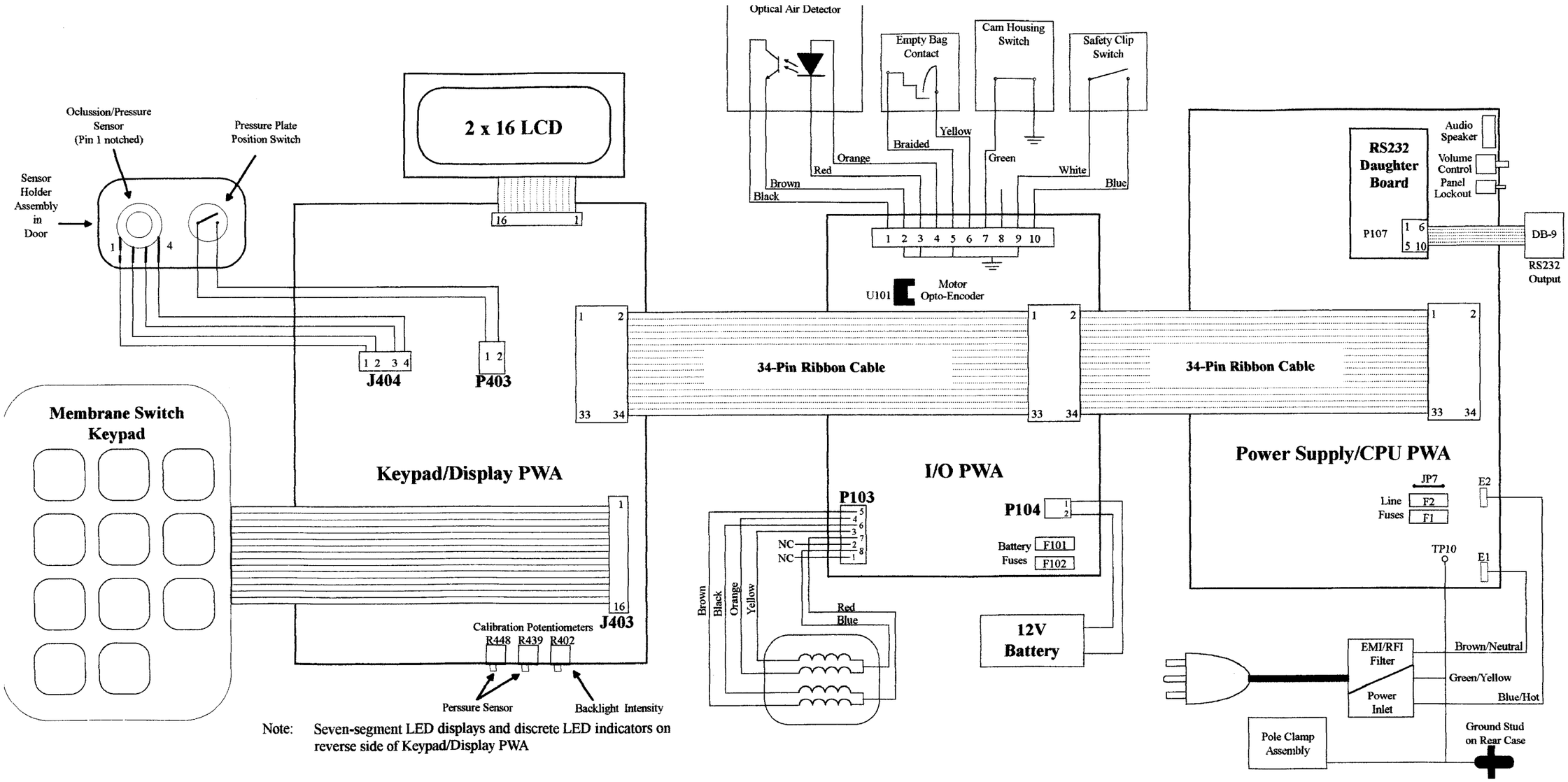


Figure 10-2 Power routeing block diagram



Note: Seven-segment LED displays and discrete LED indicators on reverse side of Keypad/Display PWA

Figure 10-3 Electrical routeing block diagram

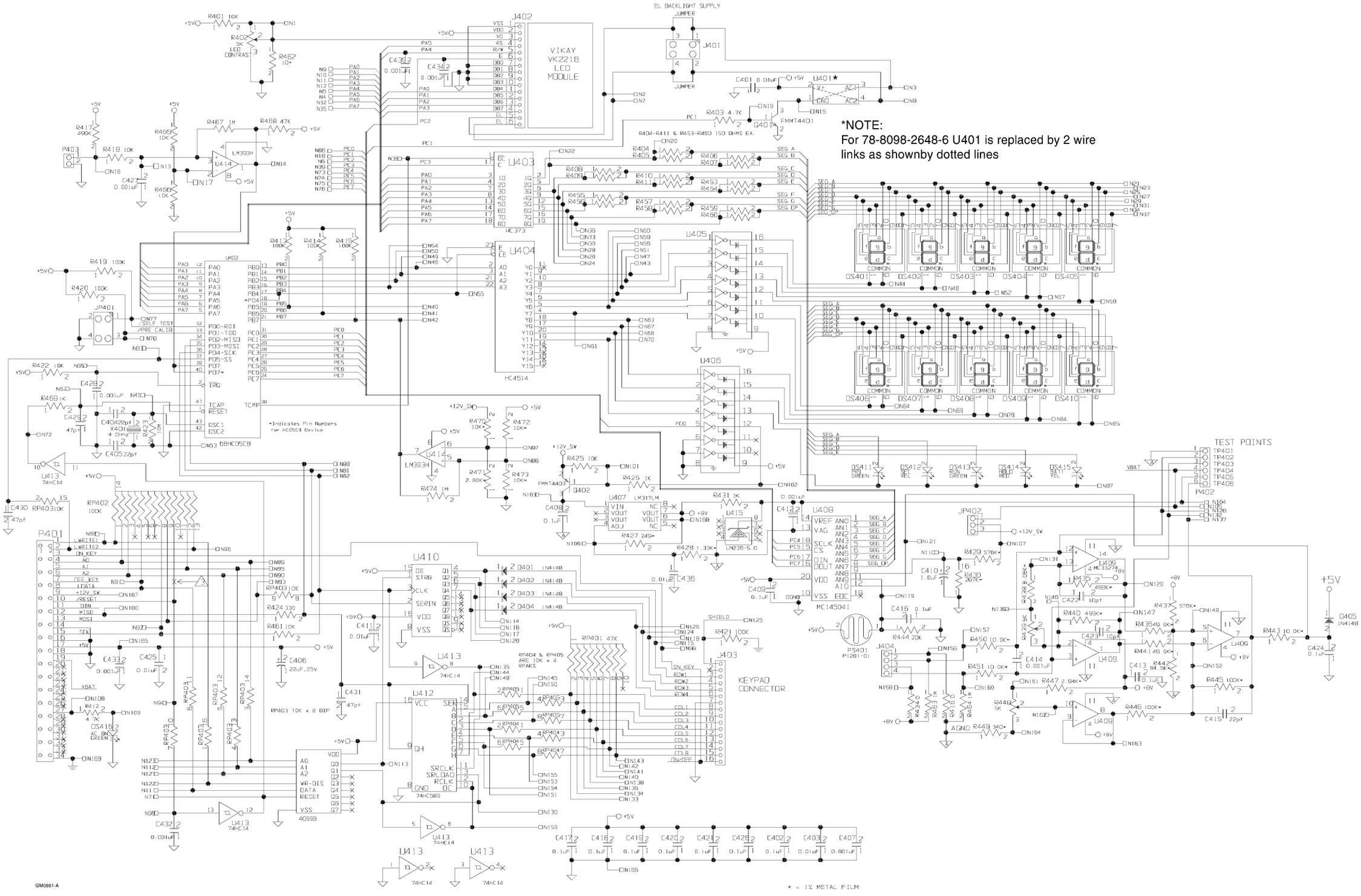
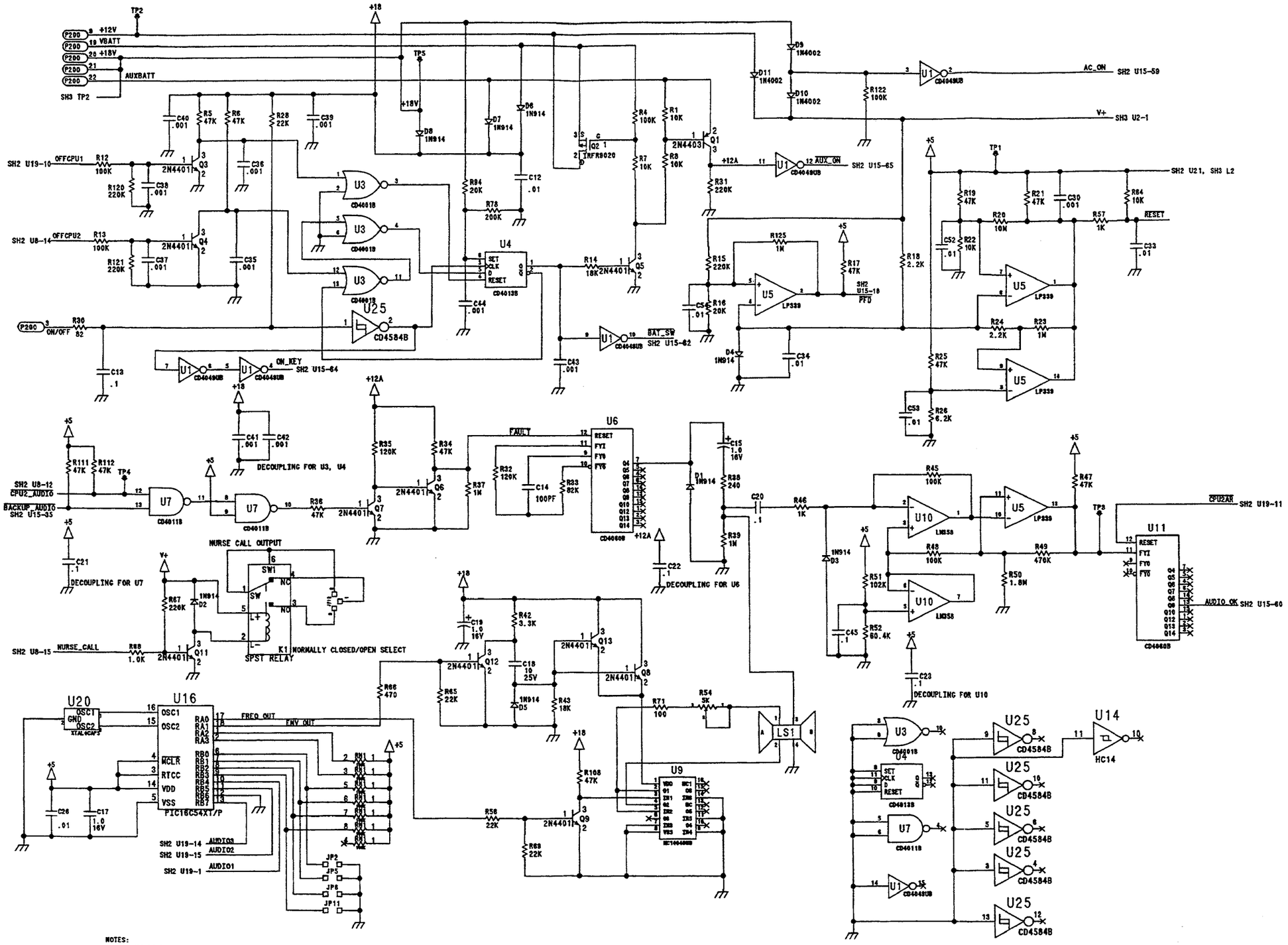

*NOTE:
For 78-8098-2648-6 U401 is replaced by 2 wire links as shownby dotted lines
*Indicates Pin Numbers for HC05C8 Device
TEST POINTS
EL BACKLIGHT SUPPLY
KEYPAD CONNECTOR
VIKAY VK2218 LCD MODULE
R404-R411 & R453-R460 150 OHMS EA.
RP404 & RP405 ARE 10K x 4 RPAKS
RP403 10K x 8 DIP
* = 1% METAL FILM
GM0881-A

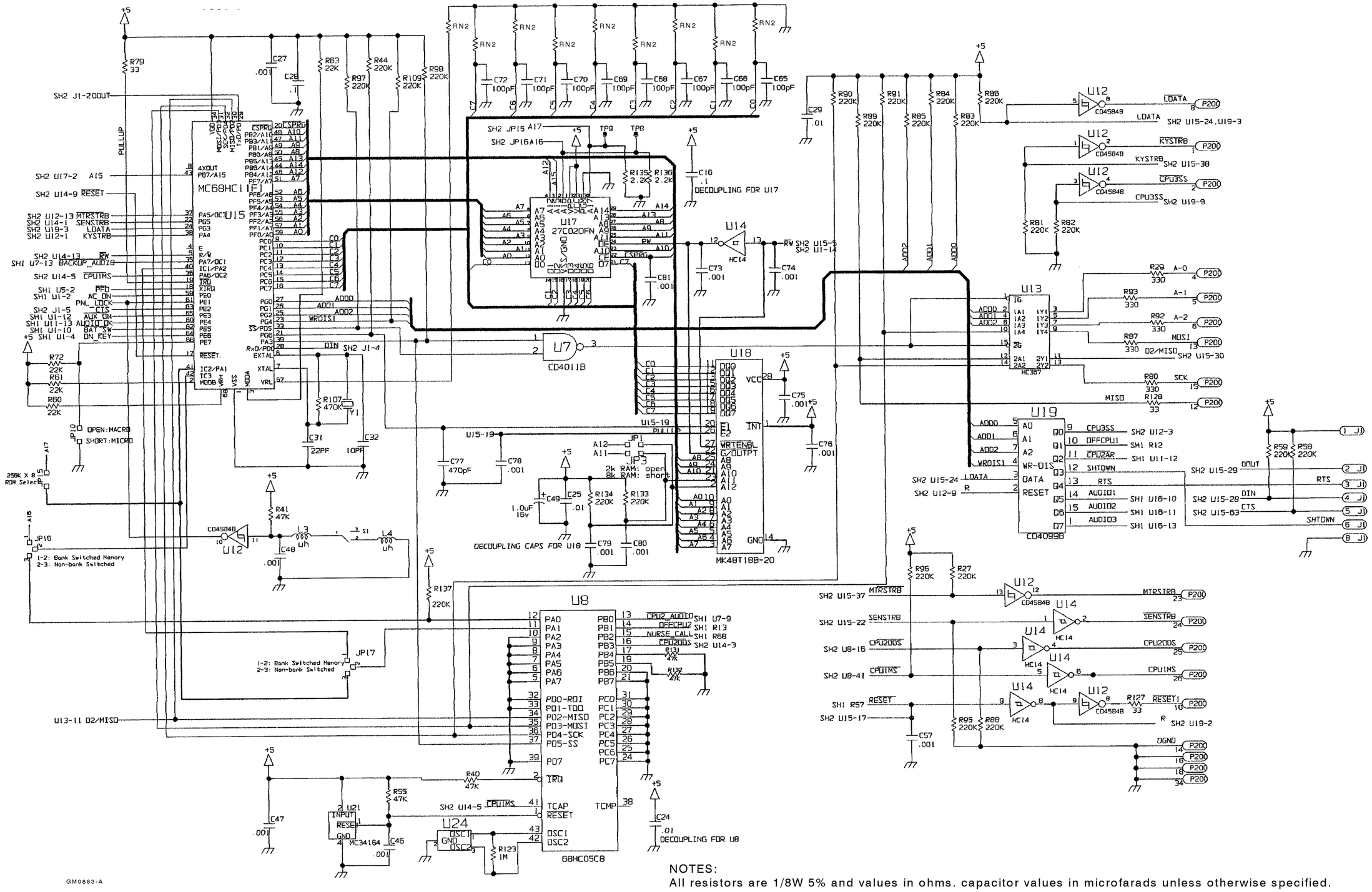
Figure 10-4 Display board schematic



NOTES:
ALL RESISTORS ARE 1/8W 5% AND VALUES IN OHMS, CAPACITOR VALUES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

GM0882-A

Figure 10-5 CPU/Power supply schematic (sheet 1 of 3)



NOTES:
All resistors are 1/8W 5% and values in ohms. capacitor values in microfarads unless otherwise specified.

Figure 10-6 CPU/Power supply schematic - CE (sheet 2 of 3)

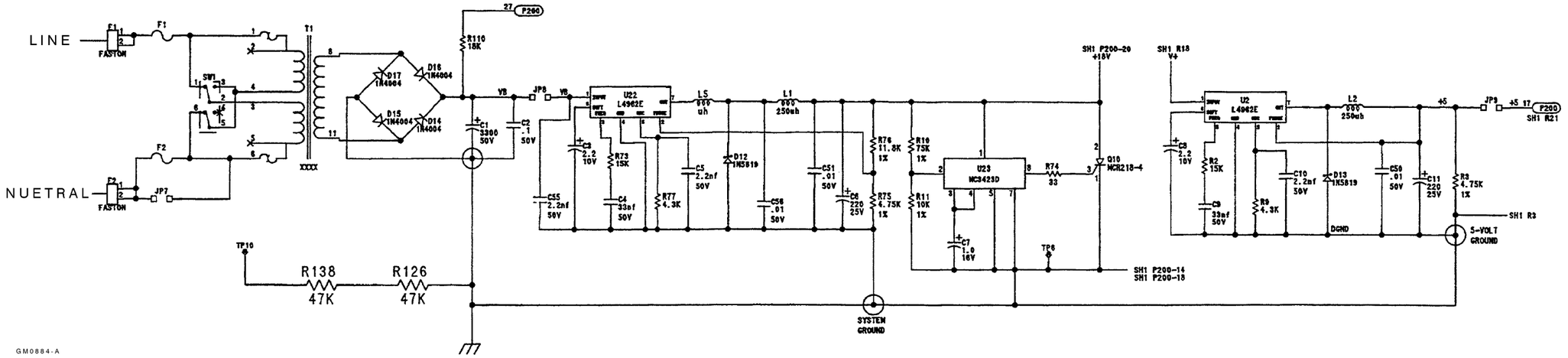


Figure 10-7 CPU/Power supply circuit (sheet 3 of 3)

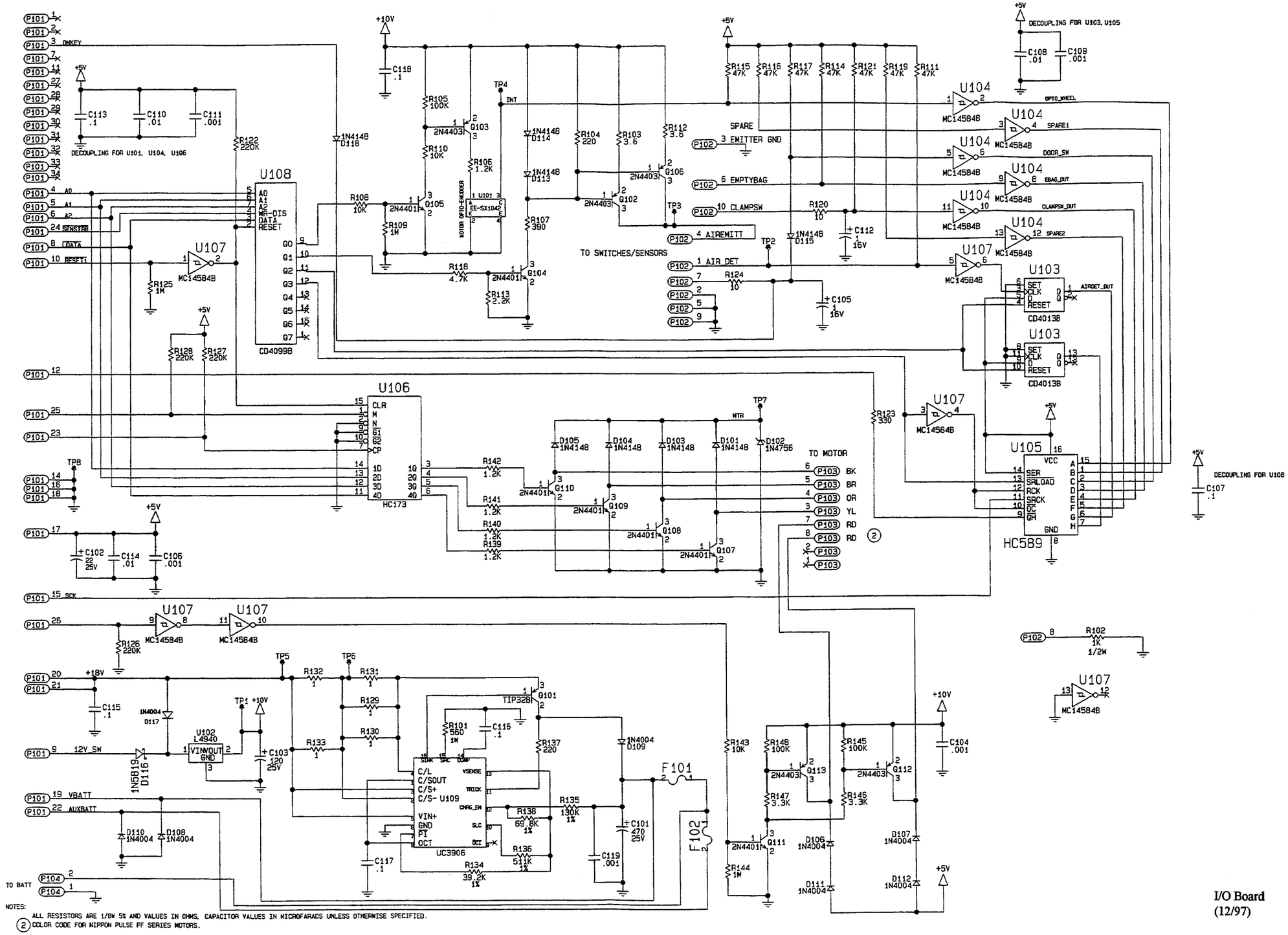
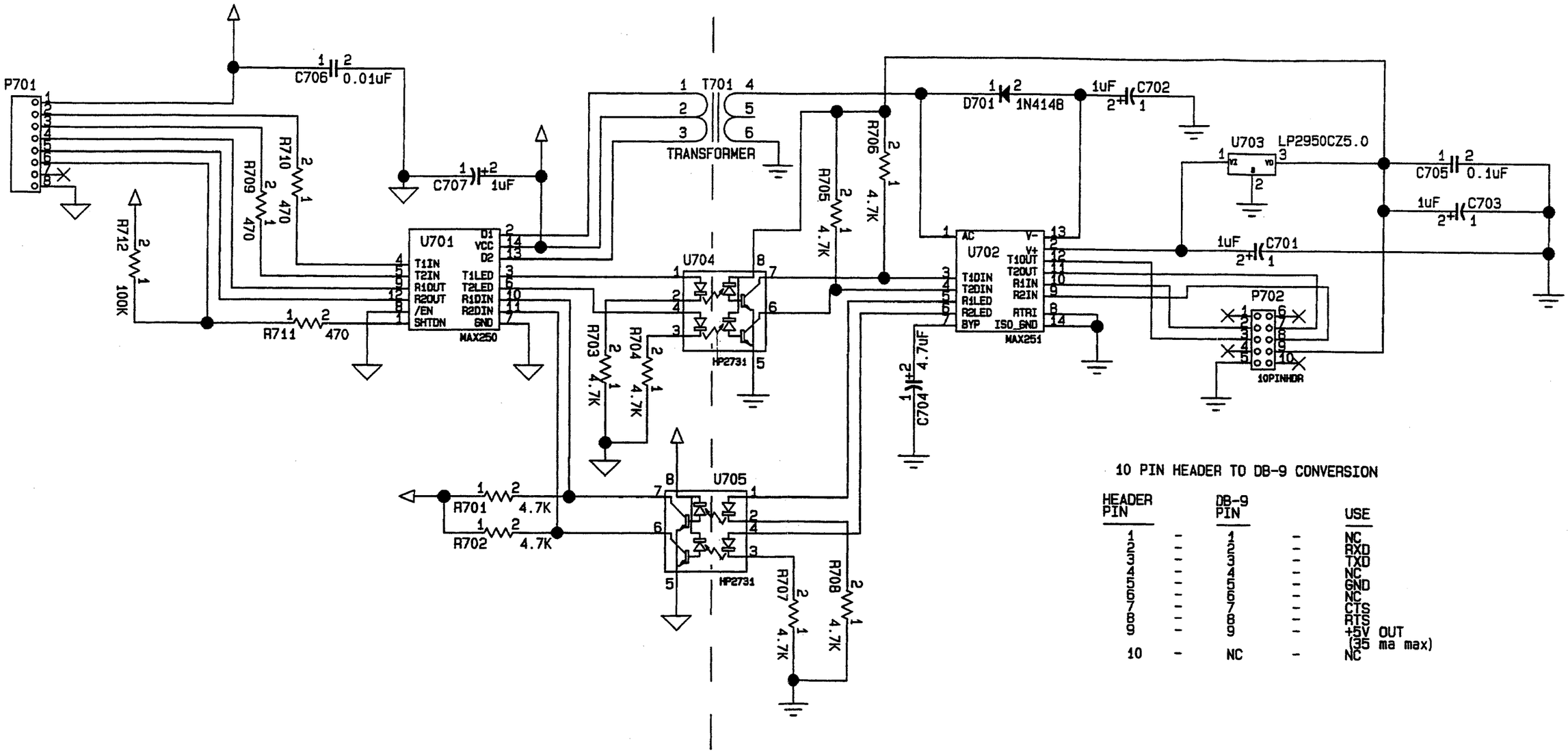


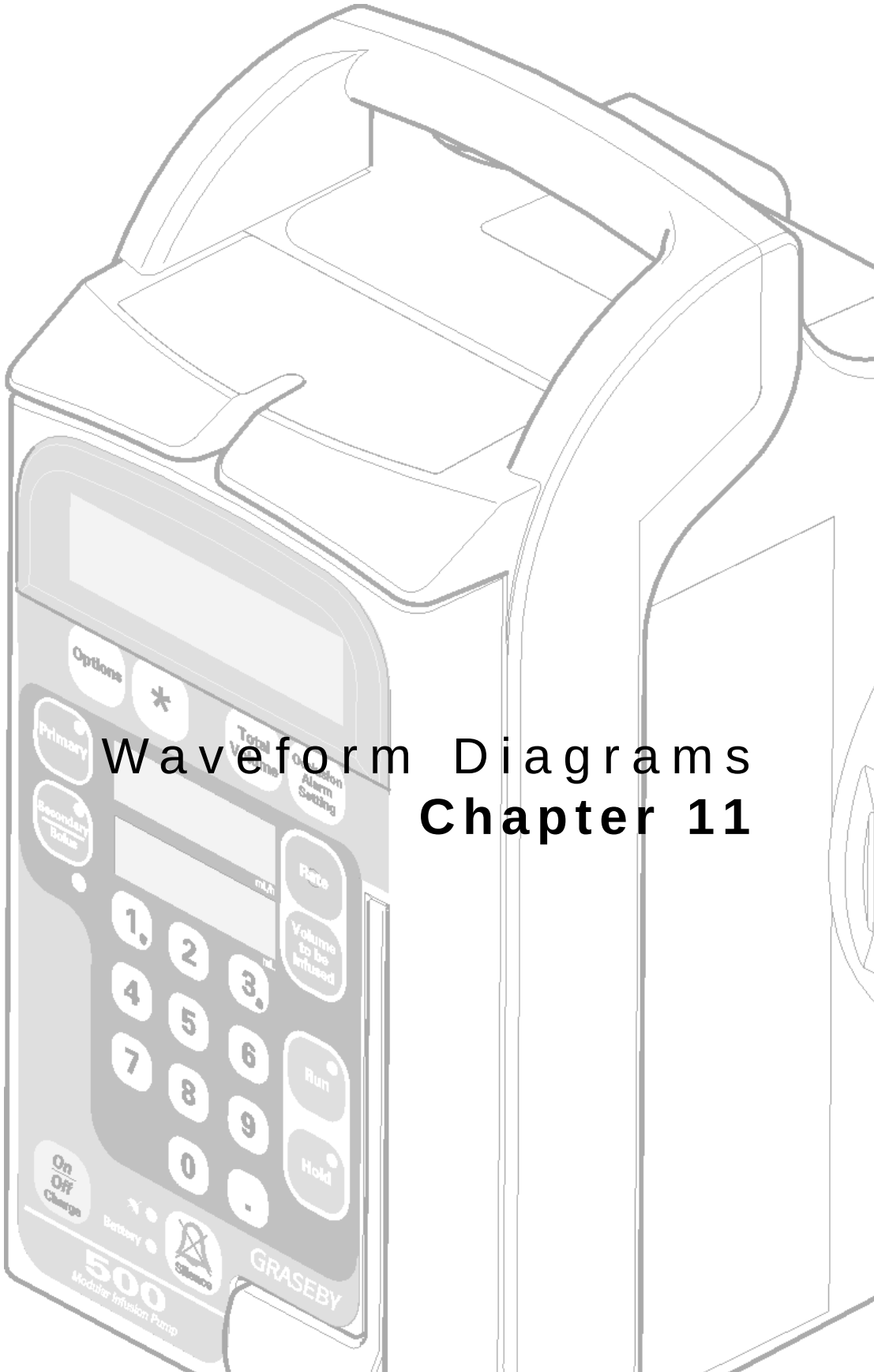
Figure 10-8 Input/Output schematic



10 PIN HEADER TO DB-9 CONVERSION

HEADER PIN		DB-9 PIN		USE
1	-	1	-	NC
2	-	2	-	RXD
3	-	3	-	TXD
4	-	4	-	NC
5	-	5	-	GND
6	-	6	-	NC
7	-	7	-	CTS
8	-	8	-	RTS
9	-	9	-	+5V OUT (35 ma max)
10	-	NC	-	NC

Figure 10-9 RS232 schematic



Waveform Diagrams
Chapter 11

Waveform Diagrams

Introduction

Oscilloscope waveforms at selected test points are shown in the following list of figures:

Figure	Title
11.1	Air detect - emitter, TP3 on I/O board
11.2	Air detect - detector, TP2 on I/O board
11.3	Motor drive pulses, TP7 on I/O board - 50 mL/h
11.4	Motor drive pulses, TP7 on I/O board - 100 mL/h
11.5	Motor drive pulses, TP7 on I/O board - 900 mL/h
11.6	Empty bag, P102 Pin 6, I/O board
11.7	Interrupter detector, TP4, I/O board

11

999 mL/h (99.9 mL/h on 3100/505)
.5 V/Div
10 μs/Div
Normal Triggering
Positive Slope

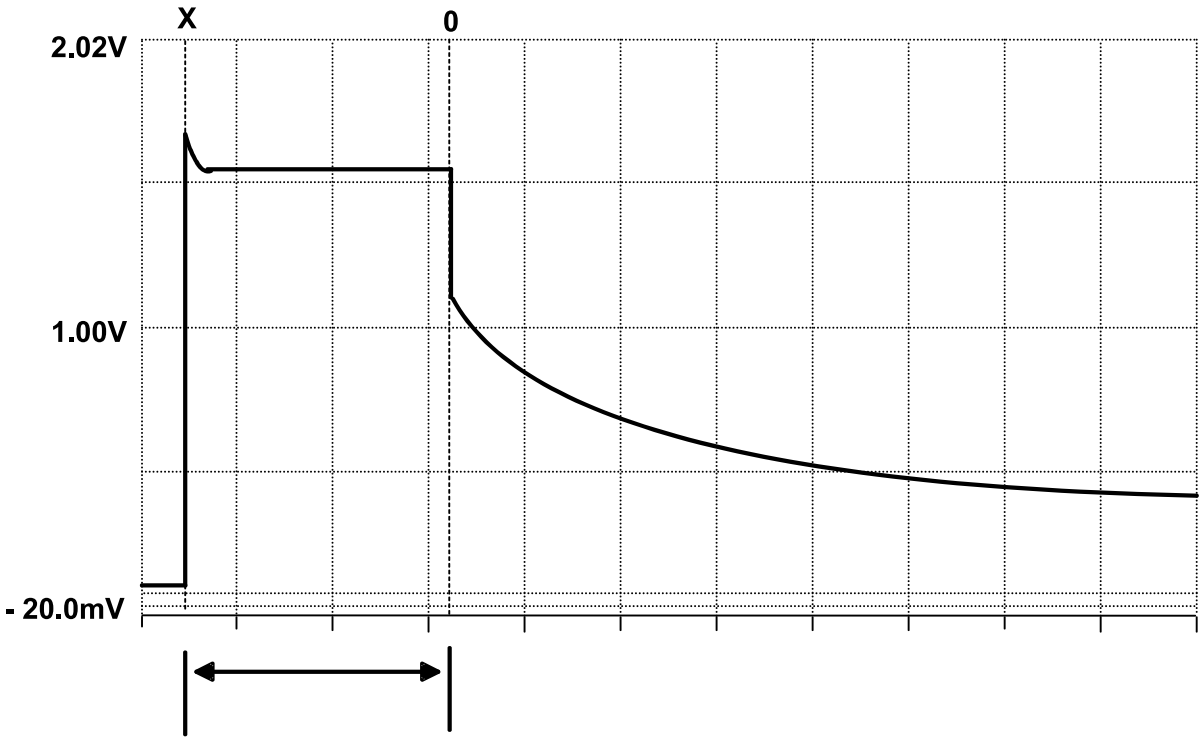


Figure 11.1 Air detect - emitter, TP3 on I/O board

999 mL/h (99.9 mL/h on 3100/505)
1 V/Div
100 μs/Div
Normal Triggering
Negative Slope

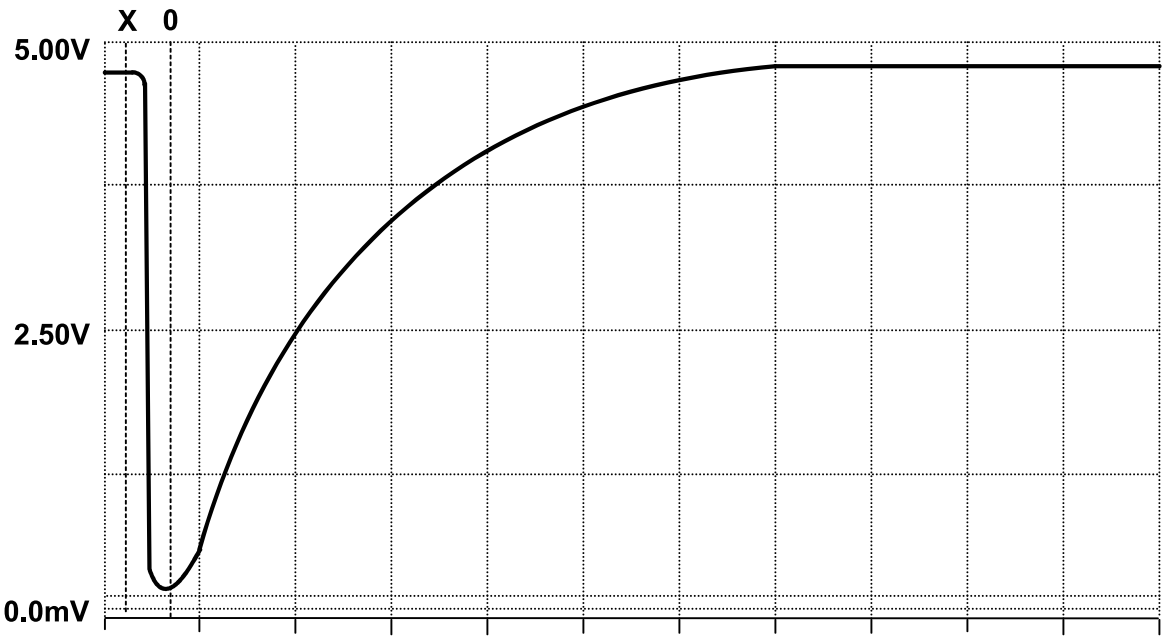


Figure 11.2 Air detect - detector, TP2 on I/O board

The wave form can be seen approximately every 5 seconds on the 3000/500 pumps, and approximately every 60 seconds on 3100/505 pumps.

11

50.0 mL/h
10 V/Div
10 ms/Div
Normal Triggering
Positive Slope

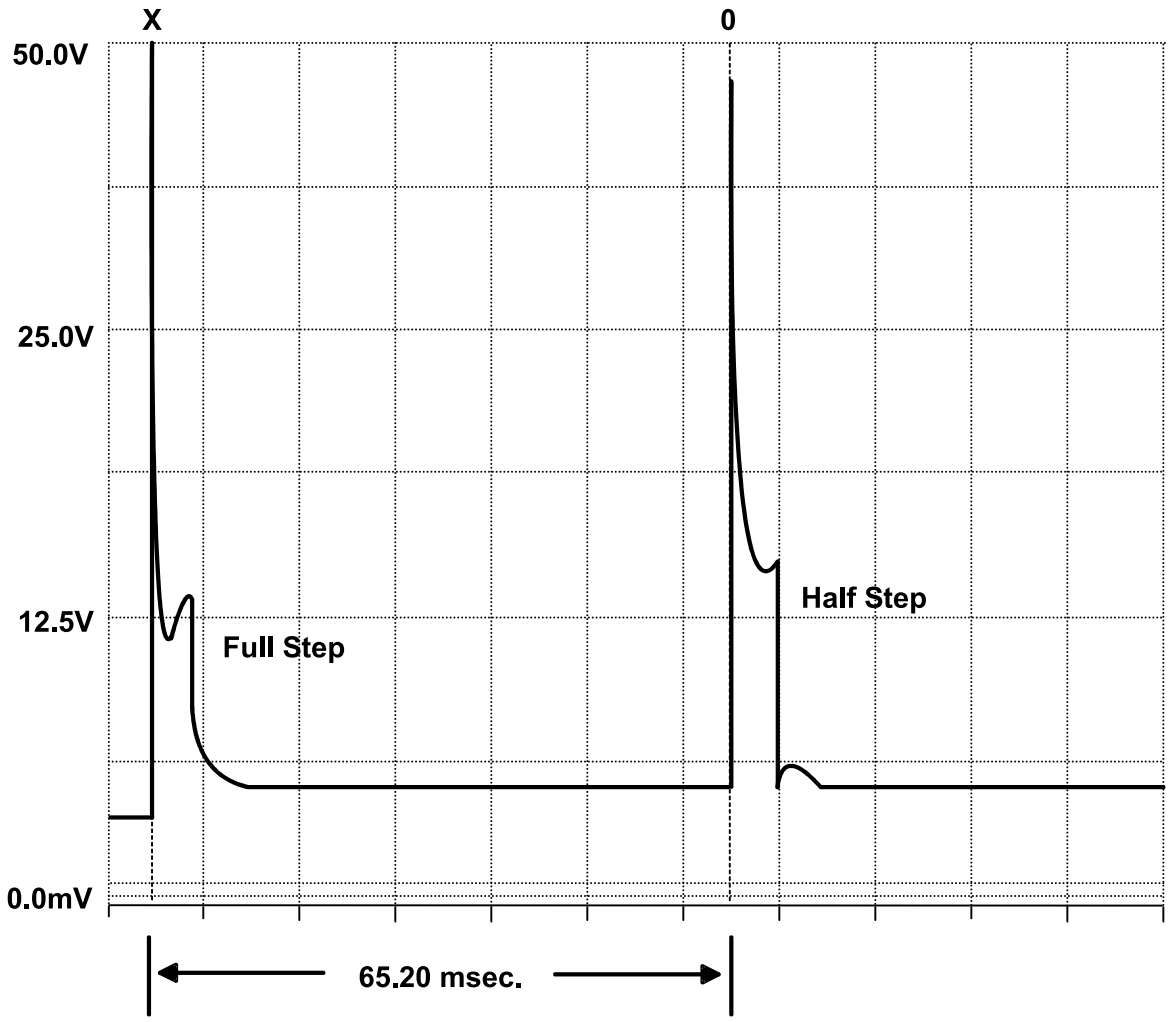


Figure 11.3 Motor drive pulses, TP7 on I/O board

Motor Drive Pulses - 50.0 mL/h

100 mL/h (99.9 mL/h on the 3100/505 pumps)
10 V/Div
5 ms/Div
Normal Triggering
Positive Slope

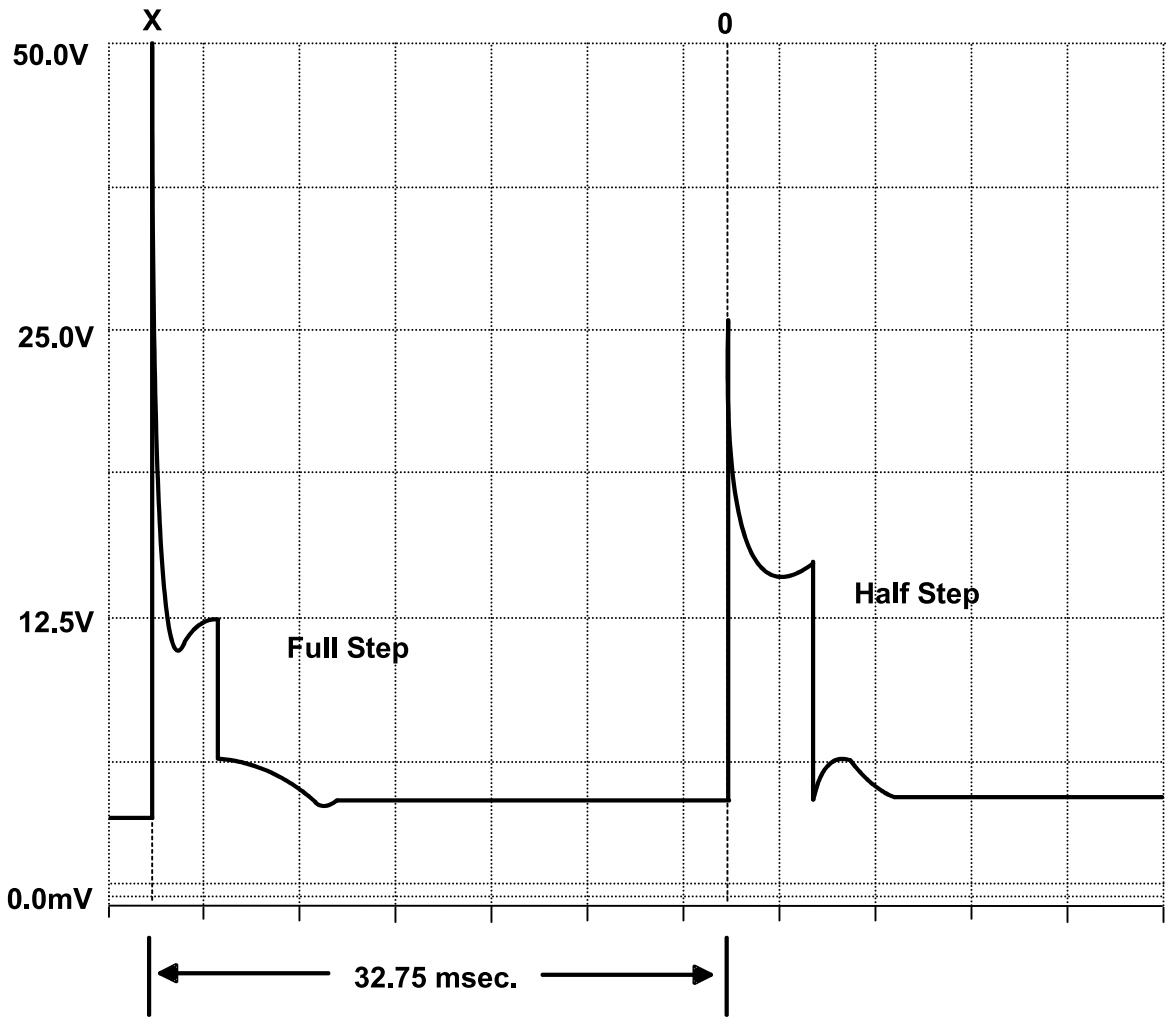


Figure 11.4 Motor drive pulses, TP7 on I/O board

Motor Drive Pulses - 100 mL/h (99.9 on the 3100/505 pumps)

3000/500 pumps only: 900 mL/h
10 V/Div
5 ms/Div
Normal Triggering
Positive Slope

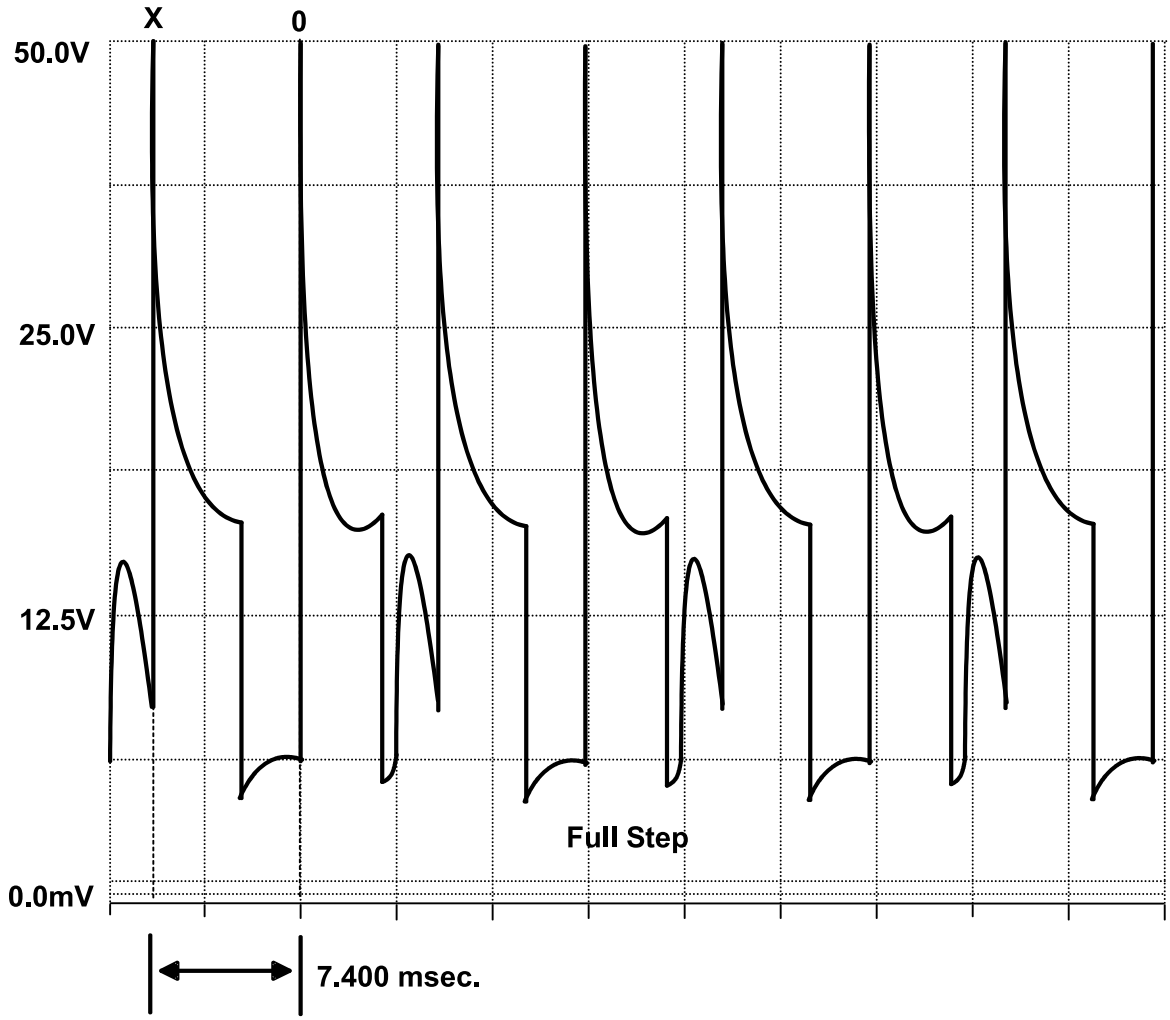


Figure 11.5 Motor drive pulses, TP7 on I/O board

Motor Drive Pulses - 900 mL/h

999 mL/hr
1 V/Div
100 ms/Div
Normal Triggering
Negative Slope

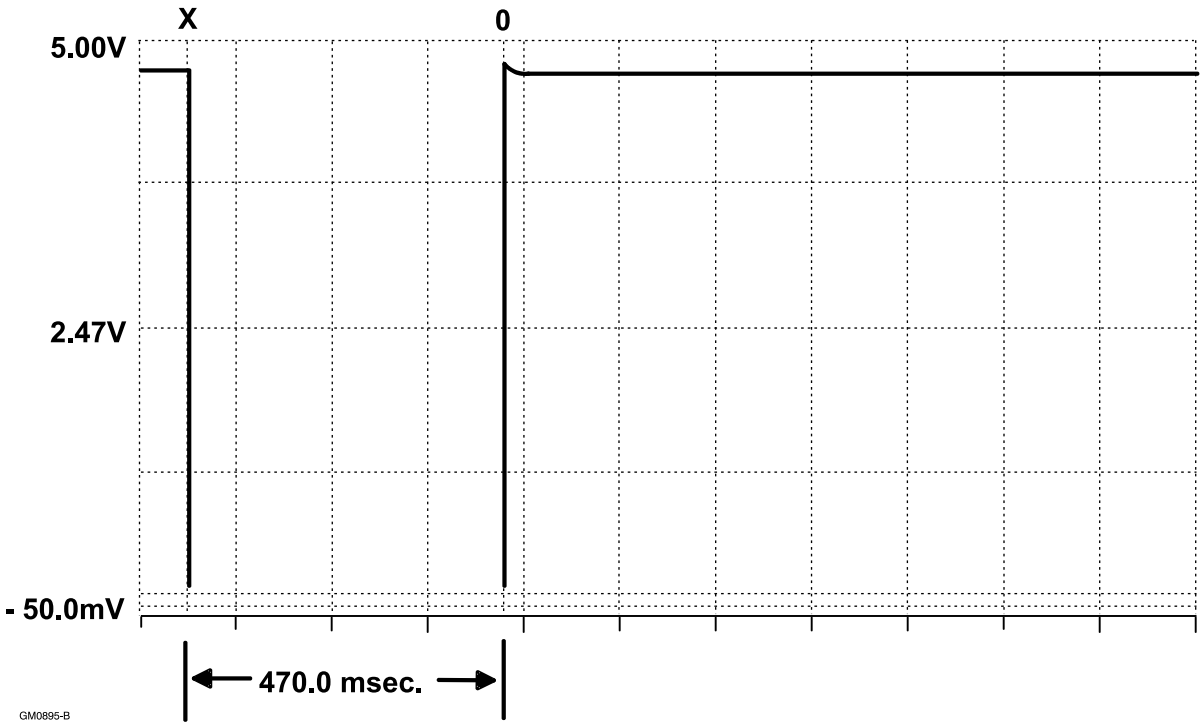


Figure 11.6 Empty bag, P102 Pin 6, I/O board

Pulse duration and time between pulses varies with pumping rate.

Example above corresponds to a typical pulse width when pump is run at 999 mL/hr on 3000/500 pumps. For 505/3100 pumps the infusion can be run in the Diagnostic mode at 999 mL/hr

999 mL/h (99.9 mL/h on the 3100/505 pumps)
1 V/Div
100 ms/Div
Normal Triggering
Negative Slope

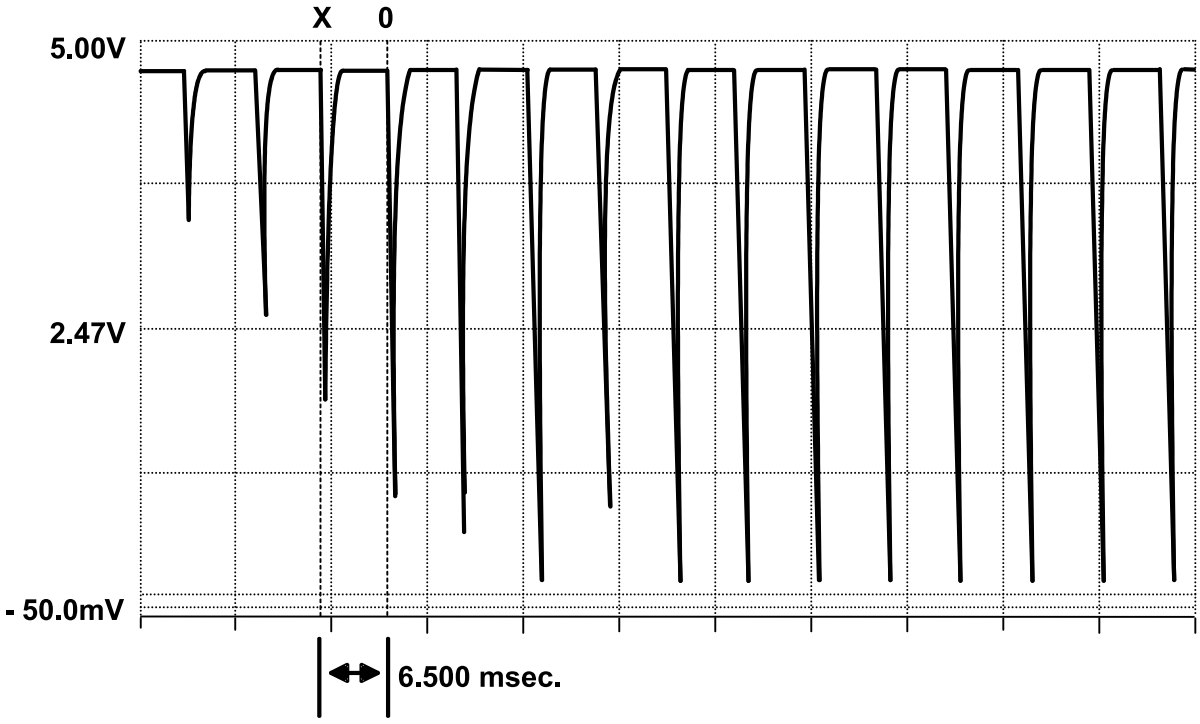
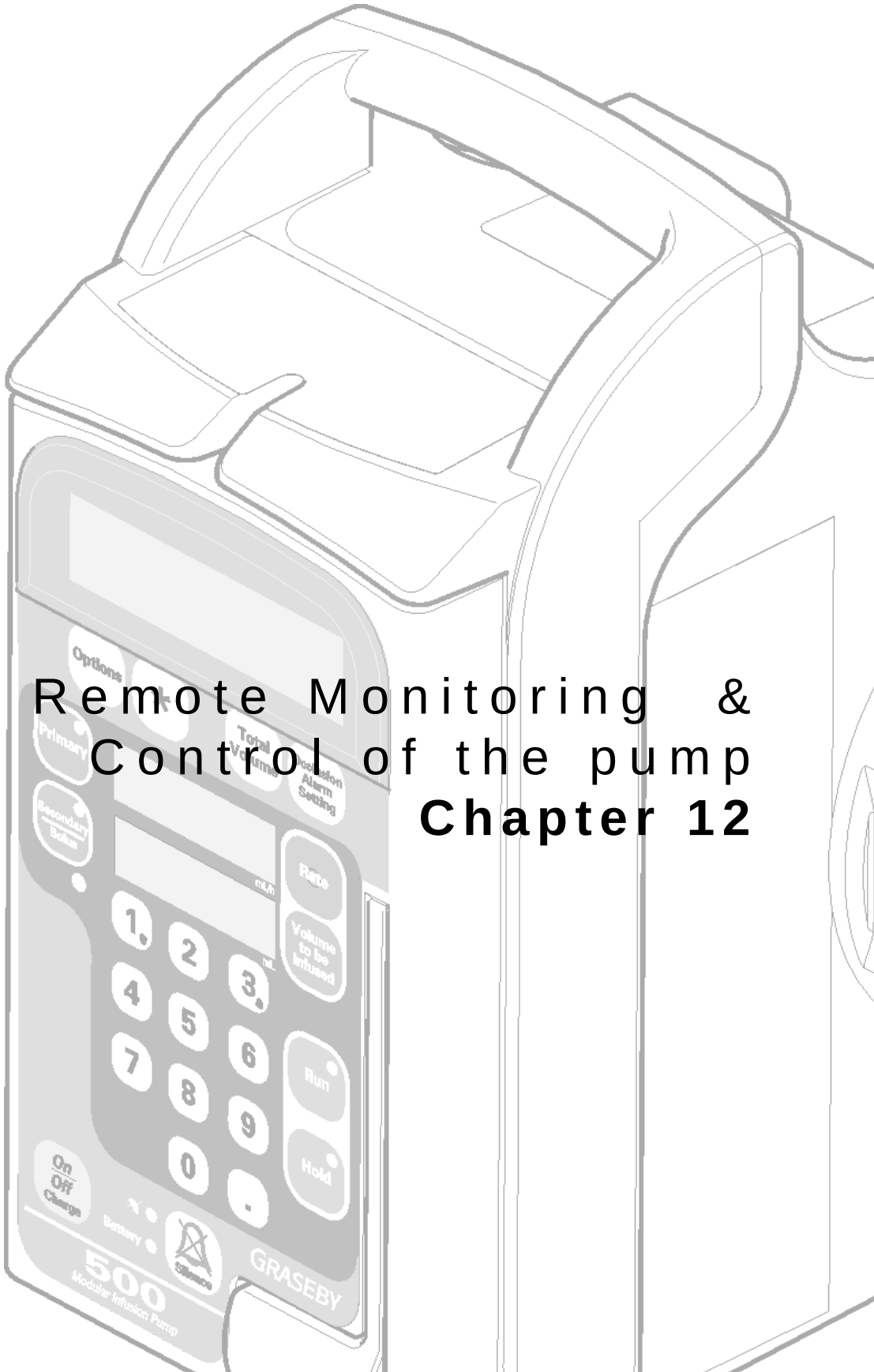


Figure 11.7 Interrupter detector, TP4, I/O board

On the 3000/500 pumps the signal appears approximately every 3 seconds at 500 mL/h, and approximately every 15 seconds on the 3100/505 pumps, at 99.9 mL/h.



Remote Monitoring & Control of the pump

Chapter 12

Remote monitoring and controlling of the pump

WARNING: **While Graseby Medical Limited have taken all reasonable steps to ensure that the pump operates correctly while under remote control, it is the responsibility of the person who designs and implements the controlling device to ensure that the resulting system (pump and controlling device) is fit for its intended purpose.** The assessment for the suitability of any software/firmware in the clinical environment to contol or receive data from the pump lies with the user of the equipment. Any connecting analogue and digital components are required to meet BS EN60950-1:2002 / IEC 60950-1(2001-10) for data processing and BS EN60601-1:1990 for medical devices. Anyone connecting additional devices to the signal input or output is a system configurator and responsible for meeting the requirements of the system standard BS EN60601-1-1:2001 / IEC 60601-1-1(2000-12). Failure to do so may result in compromised function of the product, patient injury or user injury.

Introduction

The Graseby Volumetric pumps feature an RS232 connector. This connector allows a computer which supports an RS232 (serial) port to be connected to the pump for monitoring and/or interface and control purposes.

This means that if appropriate computer software is written to communicate with the pump, a computer may be used to remotely monitor and document the patient's infusion and allow the operator to setup and change the infusion parameters.

This chapter defines the protocol to be used in software written to communicate with the pump through its RS232 connector. It is assumed that the reader is familiar with the technical aspects of computer/RS232 interface software. The units are configured for Data Circuit-terminating Equipment (DCE).

Organisation of this chapter

The chapter is in two parts. You should only read the part that applies to the CPU version of the pump to be monitored/controlled:

- The first part explains how to interface with a pump with main CPU version **0.67** and below.
- The second part, starting on page 9 explains the interface for a pump with main CPU version **0.68** and above.

Summary of commands - Version 0.67 and below

The list below summarises the monitoring and controlling commands to which a pump with a version 0.67 main CPU will respond. The syntax of these commands is described on page 12-4.

Commands for monitoring the pump - CM

The pump responds to the following monitor-only commands:

Command	*Description*
A	Alarm
D	Data
G	Time and Date
I	Enable CI (interface) commands
M	Model
N	Null

Commands for controlling the interface - CI

The pump responds to the following interface/control commands:

Command	*Description*
C	Clear infused volume
L	Set limit
O	Run (Operate)
P	Toggle pressure
R	Set rate
S	Hold (Standby)
T	Titrate

Protocol definition

Pump commands and responses are transferred in the form of records. A record consists of a string of characters in a specific order.

Character Format - Version 0.67 and below

Each character transmitted over the link is an ASCII character using

- 1 start bit
- 7 data bits
- 1 odd parity bit
- 1 stop bit.

The seven data bits are transmitted in standard order, which is least significant bit first, most significant bit last. Each character received is examined for errors, including framing and parity errors.

Transmission is software selectable to 9600 (default), 4800, 2400, 1200, 600, 300 baud.

All characters in a command or response record are to consist of printable ASCII characters only, in the range of 020 hex to 05F hex and 061 hex to 07A hex. No control characters are allowed within a record, but may be used between records as further defined below. Any error found in any single character will constitute a corrupt record and will be discarded, see *Error processing*, on page 12-7.

Record Format - Version 0.67 and below

A record consists of a string of characters that are in a specific order and follow the rules listed here. A record may in general be any length up to 47 characters including the record header and other special characters. The pump uses records with specific lengths appropriate to the command.

The general record format contains the following fields, summarised in the table below and explained in detail in the sections that follow it:

< LL C DDD SS >

Field	*Description*
<	Record header
LL	Record length (2 characters)
C	Command code
DDD	Command data (variable length)
SS	Record cheksup (2 characters)
>	Record terminator.

Record Header

As shown above, the first character of any record transmitted is an ASCII "<" character (3C hex).

This character is always recognised as the start of a new record, so it must not be included in the command parameter area.

If this character appears in the command parameter area, the partially assembled record is discarded and an attempt is made to begin assembling a new record.

Record Length

The second and third characters are made up of the ASCII digits 0-9 and letters A-F, a-f.

This two digit string, with the most significant digit in the second character position of the record, represents the total character count of the record being transmitted. The two digits form a hexadecimal value representing an 8 bit number. The count includes the header, record length digits, command code, command parameters, checksum characters and terminator.

- A minimum record will have no parameters; therefore, the minimum record length is seven characters.
- Maximum parameter length is 40, so the maximum record length is 47 (2F in hexadecimal).

Command Codes

The fourth character in any record is the command code, which is transmitted by the host to the pump to tell the pump what information is required. The pump responds with the same command in the same character position to verify that the correct command was executed.

If there is a system error, warning or invalid command, the command character in the response is replaced with a '?'. Command codes may in general be ASCII letters, with lower case letters same as upper case.

Monitoring commands

Pump response details are fully described in *Command Parameters and Data*, later in this chapter. The table below summarises the **monitoring** commands to which the pump responds:

Command	*Pump Response*	*Explanation*
A	dddd	Send alarm bytes only (in hexadecimal format)
D (V0.65 or below)	aaa.abbb.bcc.cdddd aaaabbbbcccdddd	Send all data (two formats) Response contains: Volume infused, volume limitand rate in mL/hr in decimal format, alarm bytes in hexadecimal format
D (V0.66)	aaaa.abbbb.bccc.cdddd	Send all data: different 'pump response' format, but explanation as above
G	YYMMDDhhmmss	Time and date command: YYMMDD = year month day hhmmss = hour minute second
I		Enable CI command use
M	eeeeff	Send model number and software: Model: 3000 or 3100, 500 or 505 Software version: in hexadecimal so for example, 3F represents version 0.63
N		Null command, no parameters. Used to get an echo response only

Control/Interface commands

Note: CI commands are only supported on pump versions greater than 0.53.

Interface commands initiate action by the pump and must be preceded by the CI "I" command, placing the pump into CI mode. The response to a CI command will include the volume infused, volume limit, rate, and alarm bytes formatted as described in *Command Parameters and Data*, on the next page.

Any manual keypress will cause the pump to exit CI mode. When not in CI mode, the pump will respond to any CI commands by simply echoing the received command and taking no action regarding the pump's settings or modes.

The table below shows examples of the **control/interface** commands to which the pump responds:

Command	*Form*	*Description*
C	<07CSS>	Clears infused volume command
L	<0BLddddSS>	Sets VTBI to dddd mL
L	<0CLddd.dSS>	Sets VTBI to ddd.d mL
O	<07OSS>	Sets Run mode (Operate)
P	<07PSS>	Sets Pressure mode
R	<0ARdddSS>	Sets Rate to ddd mL/hr
R	<0BRdd.dSS>	Sets Rate to dd.d mL/hr
S	<07SSS>	Sets Hold (Standby) mode
T	<0ATdddSS>	Sets Rate during Run to ddd mL/hr
T	<0BTdd.dSS>	Sets Rate during Run to dd.d mL/hr

Command Parameters and Data

The characters following the fourth character (Command code) are defined according to the command code only, except that they must be printable ASCII characters and must be counted in the record length.

There may be a minimum of zero and a maximum of 40 parameter characters. Commands from the host will have no parameters unless CI mode is active. Responses from the pump are as shown on the table starting on on page 4.

The response for the volume infused, volume limit and rate in mL/hr portion of the "D" command, and the CI commands is formatted as an ASCII string representing a decimal value.

- The string represented by "a" returns the volume infused.
- The string represented by "b" returns the volume limit.
- The string represented by "c" returns the rate in ml per hour.

Field sizes

Pump versions **0.65** and below may return either of two formats based on the values being returned:

aaa.abbb.bcc.cdddd or aaaabbbbcccdddd

If any of the values exceed the limits of the first format, then all values are reported in the second format. Note that the least significant digit in the first format is truncated when converted to the second format.

Pump version **0.66** and **0.67** return a single format:

aaaa.abbbb.bccc.cdddd

Alarm bytes

The response for the alarm bytes (dddd) portion of the "D" command and the "A" command and CI commands is formatted as a four character ASCII string representing a 16 bit Hexadecimal value.

The value is formatted as follows:

Bit #	*Description*	*Active level*
0	No flow above pump	1
1	Air in line	1
2	On HOLD alarm	1
3	Door sensor	1
4	Safety clip	1
5	System error/warning	1
6	Primary/Secondary	0 = primary, 1 = secondary
7	Run/On Hold	0 = on hold, 1 = run
8	On battery/AC	0 = AC, 1 = on battery
9	Low battery	1
10	reserved	undefined
11,12	PSI setting	00 = 2 psi, 01 = 5 psi, 10 = 10 psi 11 = undefined
13	KVO	1
14	Occlusion	1
15	reserved	undefinedCheksum

Immediately following the command parameter area (if any), a two-character checksum is given.

This value is technically a longitudinal redundancy check (LRC). The LRC is calculated as a 7-bit value. Each bit position in the LRC will be a one if the number of ones in the same bit position of all preceding characters in the record is odd.

In programming terms, starting with a zero value, all characters up to the checksum (including the record header "<") are exclusive-ORed into the accumulated LRC. The record terminator, ">", is not included in the checksum.

The LRC is converted into a two-digit hexadecimal number (ASCII representation) with the most significant digit preceding the least significant digit.

Terminator

The last character of any record transmitted by the host or pump is an ASCII ">" (3E hex). This character is recognised as the end of a record upon any occurrence, so it is not a valid character in the Command parameter area.

Additional non-message characters are allowed following the record, such as a line feed or carriage return. These characters are ignored by the pump.

Error Processing

The pump aborts command processing if a checksum, parity, framing, or format error occurs; no response is sent to the host. The pump begins looking for a record header ("<") character again. It is the host's responsibility to determine that there is no response and to interpret this as an error in transmission.

Summary of hardware connection and handshaking

Hardware connection

The Graseby Medical Volumetric pump uses a 9-pin sub D connector with female pins/male housing.

The pin configuration does not allow a standard 9 to 9 pin connector, but requires reversing of pins 2 and 3 and pins 7 and 8 at one end of the connector.

The table below shows the definition of the pins in the RS-232 connector:

Pin number	*Definition*
1	No connection
2	Receive
3	Transmit
4	No connection
5	Signal ground
6	No connection
7	Clear to send (CTS)
8	Request to send (RTS)
9	+5V out (35 mA maximum)

Handshake signals

The host asserts RTS prior to sending a command. If ready, the pump responds by asserting CTS within 20 milliseconds of RTS active. The host may keep RTS asserted indefinitely. Unless there is a fault, the pump keeps CTS asserted as long as RTS is asserted.

During a response, the host may slow down the pump communications by negating RTS. The pump finishes transmitting the character in progress, then waits until RTS goes active. If RTS remains inactive for more than 1 minute, the pump aborts the response message. When RTS is again active, the pump begins looking for a record header.

Example Commands

Version 0.65 software

Command Description	*Command Sent by Host*	*Pump Response*
Data query	<07D7F>	<1CDaaa.abbb.bcc.cddddSS>
Enable CI (control commands)	<07I72>	<16Iaaa.abbb.bcc.cddddSS>
Null	<07N75>	<07N75>
Set Limit to 1000 ml	<0BL100003>	<16Laaaa1000ccccddddSS>
Run/Operate	<07O74>	<160aaaabbbbccccddddSS>
Set Rate to 100 ml/h	<0AR1002E>	<16Raaaabbbb100ddddSS>
Hold/Standby	<07S68>	<16SaaaabbbbccccddddSS>

where:

aaaa = volume infused
bbbb = volume limit
ccc = rate in mL/hr
dddd = alarm bytes
SS = checksum

Version 0.66 software

Command Description	*Command Sent by Host*	*Pump Response*
Data query	<07D7F>	<1CDaaaa.abbbb.bccc.cddddSS>
Enable CI (control commands)	<07I72>	<16Iaaaa.abbbb.bccc.cddddSS>
Null	<07N75>	<07N75>
Set Limit to 1000 ml	<0BL100003>	<16Laaaa.a1000.0ccc.cddddSS>
Run/Operate	<07O74>	<160aaaa.abbbb.bccc.cddddSS>
Set Rate to 100 ml/h	<0AR1002E>	<16Raaaa.abbbb.b100.0ddddSS>
Hold/Standby	<07S68>	<16Saaaa.abbbb.bccc.cddddSS>

where:

aaaa.a = volume infused
bbbb.b = volume limit
ccc.c = rate in mL/hr
dddd = alarm bytes
SS = checksum

Interfacing with pump software version 0.68 and above

The information contained in this section applies to Graseby Model 3000/500 3100/505 pumps with main CPU versions greater than or equal to 0.68

Model 3000/500 3100/505 Computer Interface

The Graseby Model 3000/500 3100/505 pumps are designed to interface with a computer that supports an RS-232 serial port. The device is configured for Data Circuit-terminating Equipment (DCE).

Protocol Definition

Pump commands and responses are transferred in the form of records. A record consists of a string of characters that are in a specific order.

For each valid command record received, the pump will return a response record indicating that the command has been processed. Each command record must be completely processed before the pump will accept a new command. In other words, the pump does not queue serial commands. The host must examine and process the response to the current command, or time out, prior to sending the next command

Processing of invalid command records are discussed in the section entitled 'Return Record Format'.

Character Format - version 0.68 and above

Each character transmitted over the link will be an ASCII character using 1 start bit, 8 data bits, no parity and 1 stop bit. Transmission is software selectable through Biomedical special functions to 9600 (default), 4800, 2400, 1200, 600, 300 baud. The eight data bits are transmitted in standard order, which is least significant bit first, most significant bit last.

All characters in a command or response record are to consist of printable ASCII characters only, in the range of 020 hex to 07E hex. Control characters are ignored within a record, but may be used between records as further detailed in the section entitled 'Record Terminator'.

Command Record Format - version 0.68 and above

A command record consists of a string of characters sent from a host to the pump that are in a specific order and follow the rules listed here.

The general format can be summarized as follows:

< LLCDDDXXXX >

where:

<	= record header	1 character
LL	= record length	2 characters
C	= command code	1 character
DDD	= command parameters	variable length - 0 to 17 characters
XXXX	= record CRC	4 characters
>	= record terminator	1 character
		Total - 9 to 26 characters

Record Header

As shown above, the first character of any record transmitted will be an ASCII "<" character (3C hex). This character will be recognized as the start of a new record upon any occurrence. Therefore, this character should not appear anywhere within the record, other than as the record header. Should this character appear within the record, the partially assembled record will be discarded and an attempt will be made to begin assembling a new record. The pump will not respond to a partially assembled record. See the section entitled 'Return Record Format' for information regarding when a return record will be sent.

Record Length

The second and third characters are made up of the ASCII digits 0-9 and letters A-F, a-f. This two digit string, with the most significant digit in the second character position of the record, represents the total character count of the record being transmitted. The two digits form a **hexadecimal value** representing an 8 bit number. The count includes the header, record length digits, command code, command parameters, CRC characters and terminator. A minimum record will have no parameters; therefore, the minimum record length is 9 characters. Maximum allowed parameter length is 17, so the maximum allowed record length is 26 (1A in hexadecimal). When a message is received that is too short, too long, or the record length does not equal LL, the pump will send a ‘return record’ indicating the problem. See the section entitled 'Return Record Format' for information regarding return records.

Command Code

The fourth character in any record shall be the command code, which is transmitted by the host to the pump to tell the pump what information or action it wishes. Command codes are ASCII letters, case sensitive. When the pump receives a character which is not one of the supported commands specified below, the pump will indicate ‘Invalid Command Code’ in the ‘return code field.’

CM (Computer Monitor) commands are used for monitoring pump information. The *Return Record Format* section gives details of parameters and return information. The pump shall respond, when queried, to the following "CM" or monitor-only commands:

CM (Monitor) Command Code	*Name*
A	Alarm/Status Request
D	Infusion Data Request
G	Time and Date Request
I	CI Commands Enable
M	Pump Model Number Request
Y	Pump Serial Number Request

CI (Computer Interface) commands initiate action by the pump and must be preceded by the CM "I" command, placing the pump into CI mode.

Entry to CI Mode :

Like other CM commands, the pump responds to the "I" command even when powered down on AC. Receipt of an "I" command will enable CI mode when the following conditions are met. If these conditions are not met, the return code in the return record will be set to 'Invalid Mode' and no command data will be returned as part of the response.

- The pump is in Primary mode. This excludes Secondary, Rate Taper, and Dosing modes.
- The default Primary mode screen is displayed. This Primary mode default screen text is "XXXXX mL this infusion".
- No Rate or VTBI entry is in process.
- The pump is not in Run Mode.

When not in CI mode, the pump will respond to any CI command by indicating 'invalid mode' in the 'return code field.' This signifies that the command is not supported for the current pump state. See the "I" command's entry in Table I for further details.

Any manual key press while powered on an unlocked key will cause the pump to terminate CI mode. See the command 'Keypad Lockout Setup' in Table I for further details on locked/unlocked keys.

The pump will also respond to the following “CI” or interface/control commands:

CI (Interface) Command Code	*Name*	*Parameter Needed*
B	Silence Key Keypress	
C	Infused Volume Clear	
E	Time and Date Set	✓
F	Pump On or Off.	✓
K	Keypad Lockout Setup	✓
L	VTBI Set	✓
N	Open Top Valve	✓
O	Run Mode Enter (Begin pumping).	
P	Occlusion Pressure Set (2,5, or 10 psi).	✓
R	Rate Value Set	✓
S	Hold Mode Enter (Stop pumping).	
T	Titrate (Rate change while pumping).	✓
X	User LCD Text Setup	✓

Command Parameters

Any characters following the command code and preceding the CRC characters are parameters specific to the command code. There may be a minimum of zero and a maximum of 17 parameter characters. Responses from the pump are described in Table 1 and the section entitled 'Return Record Format'. When the pump receives a CI command that requires a parameter, and that parameter is out of range or missing, the pump will indicate ‘invalid parameter’ in the ‘return code field.’

CRC

Immediately following the parameter area (if any), a four character CRC is given. The CRC is calculated as a 16-bit value and includes the record header through the parameter characters. The record terminator, ">", and CRC characters are not included in the CRC.

When the pump receives a message where the CRC field does not match calculated message CRC, the pump will indicate ‘Invalid CRC Field’ in the ‘return code field.’

The CRC table and algorithm used are shown below in a 'C' code example:

```
unsigned int crctable[256] =
{
 0x0000, 0x1189, 0x2312, 0x329B, 0x4624, 0x57AD, 0x6536, 0x74BF,
 0x8C48, 0x9DC1, 0xAF5A, 0xBED3, 0xCA6C, 0xDBE5, 0xE97E, 0xF8F7,
 0x0919, 0x1890, 0x2A0B, 0x3B82, 0x4F3D, 0x5EB4, 0x6C2F, 0x7DA6,
 0x8551, 0x94D8, 0xA643, 0xB7CA, 0xC375, 0xD2FC, 0xE067, 0xF1EE,
 0x1232, 0x03BB, 0x3120, 0x20A9, 0x5416, 0x459F, 0x7704, 0x668D,
```

```
 0x9E7A, 0x8FF3, 0xBD68, 0xACE1, 0xD85E, 0xC9D7, 0xFB4C, 0xEAC5,
 0x1B2B, 0x0AA2, 0x3839, 0x29B0, 0x5D0F, 0x4C86, 0x7E1D, 0x6F94,
 0x9763, 0x86EA, 0xB471, 0xA5F8, 0xD147, 0xC0CE, 0xF255, 0xE3DC,
 0x2464, 0x35ED, 0x0776, 0x16FF, 0x6240, 0x73C9, 0x4152, 0x50DB,
 0xA82C, 0xB9A5, 0x8B3E, 0x9AB7, 0xEE08, 0xFF81, 0xCD1A, 0xDC93,
 0x2D7D, 0x3CF4, 0x0E6F, 0x1FE6, 0x6B59, 0x7AD0, 0x484B, 0x59C2,
 0xA135, 0xB0BC, 0x8227, 0x93AE, 0xE711, 0xF698, 0xC403, 0xD58A,
 0x3656, 0x27DF, 0x1544, 0x04CD, 0x7072, 0x61FB, 0x5360, 0x42E9,
 0xBA1E, 0xAB97, 0x990C, 0x8885, 0xFC3A, 0xEDB3, 0xDF28, 0xCEA1,
 0x3F4F, 0x2EC6, 0x1C5D, 0x0DD4, 0x796B, 0x68E2, 0x5A79, 0x4BF0,
 0xB307, 0xA28E, 0x9015, 0x819C, 0xF523, 0xE4AA, 0xD631, 0xC7B8,
 0x48C8, 0x5941, 0x6BDA, 0x7A53, 0x0EEC, 0x1F65, 0x2DFE, 0x3C77,
 0xC480, 0xD509, 0xE792, 0xF61B, 0x82A4, 0x932D, 0xA1B6, 0xB03F,
 0x41D1, 0x5058, 0x62C3, 0x734A, 0x07F5, 0x167C, 0x24E7, 0x356E,
 0xCD99, 0xDC10, 0xEE8B, 0xFF02, 0x8BBD, 0x9A34, 0xA8AF, 0xB926,
 0x5AFA, 0x4B73, 0x79E8, 0x6861, 0x1CDE, 0x0D57, 0x3FCC, 0x2E45,
 0xD6B2, 0xC73B, 0xF5A0, 0xE429, 0x9096, 0x811F, 0xB384, 0xA20D,
 0x53E3, 0x426A, 0x70F1, 0x6178, 0x15C7, 0x044E, 0x36D5, 0x275C,
 0xDFAB, 0xCE22, 0xFCB9, 0xED30, 0x998F, 0x8806, 0xBA9D, 0xAB14,
 0x6CAC, 0x7D25, 0x4FBE, 0x5E37, 0x2A88, 0x3B01, 0x099A, 0x1813,
 0xE0E4, 0xF16D, 0xC3F6, 0xD27F, 0xA6C0, 0xB749, 0x85D2, 0x945B,
 0x65B5, 0x743C, 0x46A7, 0x572E, 0x2391, 0x3218, 0x0083, 0x110A,
 0xE9FD, 0xF874, 0xCAEF, 0xDB66, 0xAFD9, 0xBE50, 0x8CCB, 0x9D42,
 0x7E9E, 0x6F17, 0x5D8C, 0x4C05, 0x38BA, 0x2933, 0x1BA8, 0x0A21,
 0xF2D6, 0xE35F, 0xD1C4, 0xC04D, 0xB4F2, 0xA57B, 0x97E0, 0x8669,
 0x7787, 0x660E, 0x5495, 0x451C, 0x31A3, 0x202A, 0x12B1, 0x0338,
 0xFBCF, 0xEA46, 0xD8DD, 0xC954, 0xBDEB, 0xAC62, 0x9EF9, 0x8F70
};
unsigned int                // Returns Calculated CRC value
CalculateCRC16(
    unsigned int crc_seed,  // Seed for CRC calculation
    void *c_ptr,            // Pointer to byte array to perform CRC on
    unsigned int len)       // Number of bytes to CRC
    {
unsigned char *c = c_ptr;
unsigned int crc = crc_seed;
    while (len--)
        crc = (crc << 8) ^ crctable[((crc >> 8) ^ *c++)];
    return (crc);
}
```

This CRC algorithm is characterized as follows:

CRC Name	:	CRC-16
Width	:	16 Bits
Polynomial Used	:	1189 (hex)
Seed Value	:	FFFF (hex)
Reflected Input/Output	:	No
Exclusive OR Output	:	No
Test CRC for string "123456789"	:	5502 (hex)

For further background, see the Public Domain Internet Document “A Painless Guide to CRC Error Detection Algorithms”
© Ross Williams 1993 Keywords: crc_v3.txt

Record Terminator

The last character of any record transmitted by the host or pump will be an ASCII ">" (3E hex). The use of this character is not allowed in the command parameter area.

Additional non-message characters are allowed following the record, such as a line feed or carriage return. These are not required and the pump ignores such characters.

Return Record Format

A return record consists of a string of characters sent from the pump to the host as a result of a command record sent to the pump. The general format can be summarized as follows:

< LLRAAAAAADDDXXXX >
where:

<	= record header	1 character
LL	= record length	2 characters
R	= return code	1 character
AAAAAA	= alarm bytes	6 characters
DDD	= command data	variable length - 0 to 17 characters
XXXX	= record CRC	4 characters
>	= record terminator	1 character
		Total - 15 to 32 characters

The record header, record length, CRC field, and record terminator are as described above for the command record, with the following exceptions/additions:

- The valid values in the length field can be from 15 to 32 bytes.
- The command parameters are replaced with the alarms bytes and the variable length command data.
- The command code is replaced with a return code.

The return code field of the return record can be any of the following:

0 - Command Accepted	No problems were detected with command or its execution
1 - Invalid Length Field	Length field does not match actual message length
2 - Message too short	Message does not meet minimum length requirements
3 - Message too long	Message exceeds maximum allowed length
4 - Invalid CRC Field	CRC field does not match calculated message CRC
5 - Invalid Command Code	The command code is not for one of the supported commands
6 - Invalid Parameter	Parameter is out of range or missing - See Table 1
7 - Invalid Mode	See Table I for modes when commands are not valid

The host should always check this return code and verify that it is 'Command Accepted'. In addition the host should verify through the use of other information returned from the pump, that a command was carried out properly. (e.g. after executing the 'change rate' command,

verify that the return code is 'Command Accepted' and that the rate value returned is indeed the rate that was expected). *Conversely, if the return code is not 'Command Accepted', the host should ignore the command data (DDD) returned because it may be invalid or non-existent.*

Every attempted command that includes a record header and a record terminator will receive a return record that follows the above format.

The alarm bytes field is defined as follows (byte numbers increase left to right, bits increase right to left):

Byte	*Bit #*	*Description*	*Active level*
0	0-4	Current Alarm number	$00= None,$01- $11=Alarm Number 01 (hex) LOW_BATTERY 02 (hex) DOSE_SET_INCOMPLETE 03 (hex) DOSE_CHG_UNACCEPTBL 04 (hex) DOSE_CHG_INCOMPLETE 05 (hex) RATE_CHANGE_INCOMPLETE 06 (hex) KVO 07 (hex) ON_HOLD 08 (hex) EMPTY_BAG 09 (hex) OCCLUSION 0A (hex) AIR 0B (hex) DOOR_OPEN 0C (hex) MOTOR_REV_STALL 0D (hex) SAFETY_CLIP 0E (hex) PRESSURE_PLATE 0F (hex) DEAD_BATTERY 10 (hex) SYSTEM_WARNING 11 (hex) SYSTEM_ERROR 12 (hex) SERVICE_DUE 13 (hex) SECONDARY_STOP 14 (hex) PRESET_LIMITS_EXCEEDED
0	5	Audible Signal	0= Off, 1= On
0	6	Main Screen Displayed	0= No, 1= Yes
0	7	CI Mode	0= Disabled, 1= Enabled
1	0	Primary/Secondary	0 = primary, 1 = secondary
1	1	Run/On Hold	0 = on hold, 1 = run
1	2	KVO State	0= Programmed Rate, 1=KVO Rate
1	3	On battery/AC	0 = AC, 1 = on battery
1	4	Battery Strength	0= Normal,1=Low/Dead
1	5	Door sensor	0= Closed, 1=Open
1	6	Safety clip	0= Not In-Place, 1= In-Place
1	7	Cassette Loaded	0= No, 1= Yes
2	0	Keypad Locked	0= No, 1= Yes
2	1-2	PSI setting	00 = 2 psi, 01 = 5 psi, 10 = 10 psi 11 = undefined
2	3	Power Mode	0= Power Down/AC 1= Power Up/AC/Battery
2	4	User Defined LCD Text	0=No, 1= Yes
2	5-7	reserved	undefined

For further details, see the next page.

Byte	*Bits*	*Description*
0	0-4	represent the current alarm number. A value of zero implies no alarm. In general, an alarm will start an audible signal and change the standard message to an alarm specific message. The message and signal can often be cleared without clearing the alarm. Many alarms will reassert themselves after a short time by reenabling the audible signal and specific message.
	5	tracks the audible signal heard by the operator.
	6	tracks the message displayed to the operator. The pump software has a main screen in primary and secondary to which it defaults. This main screen may be overridden by an alarm or operator intervention. When this main screen is displayed, the bit will be set to true, even if user defined LCD text is being displayed.
	7	tracks the CI Mode. See the CM 'I' command in Table I and *Exiting CI Mode – Terminated vs Disabled* for further details.
1	0	tracks the Pump Delivery mode of Primary or Secondary.
	1	tracks the Run state of the pump
	2	tracks KVO mode, and is only valid when the pump is in the Run state.
	3	tracks the Pump Power Source
	4	tracks battery strength and is only valid when the power source is battery.
	5	tracks the door sensor.
	6	tracks the Safety Clip sensor
	7	tracks the Cassette Loaded sensors of pressure value and Pressure Plate Switch Position
2	0	tracks the Keypad state. Any lock, total or partial, from any source, manual or the serial port, reports the keypad as locked. The keypad may remain locked after a serial command attempts to unlock the keypad, if the manual lock is set. The keypad can always be unlocked by manually setting and manually clearing a keypad lock.
	1-2	track the Pressure Limits used to declare an occlusion.
	3	3 tracks the Power mode. The pump is powered up, down on A/C, or down on battery. The third mode is not reported as powered down on battery also implies the lack of serial support.
	4	represents user defined LCD text. The pump software will return a 1 if user LCD text has been defined (though it may not necessarily be displayed at that time). Otherwise it will return a 0.
	5-7	unused

The response to all accepted CI commands will include the volume infused, volume limit, rate, and alarm bytes formatted as described in Table 1.

Command Summary

The following table defines all command records and return records.

Table 1 - Command codes, descriptions, parameters, and return records.

Notes: In the table below, *LL* = length characters, *R* = return code, *XXXX* = CRC characters, *AAAAAA*=Alarm bytes as described in the section entitled 'Return Record Format'. Commands are case sensitive.

Command Code/Type and Name	*Modes when command is not supported*	*Command Record Definition*	*Return Record Definition for 'Command Accepted' Return Code*
A (CM) - Alarm/Status Request	None	<*LLAXXXX*>	<*LLRAAAAAAXXXX*> where *AAAAAA* is 3 alarm bytes encoded as hex ascii characters as described in the section entitled 'Return Record Format'.
D (CM) - Infusion Data Request	None.	<*LLDXXXX*>	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where: aaaa.a is volume infused in decimal format bbbb.b is volume limit in decimal format ccc.c is rate in mL/h in decimal format
G (CM) - Time and Date Request	None.	<*LLGXXXX*>	<*LLRAAAAAA*YYMMDDhhmmss*XXXX*> where decimal parameters are : YY = Year MM = Month DD = Day hh = hour mm = minute ss = second Note: the range of valid years is 1989-2088

Command Code/Type and Name	*Modes when command is not supported*	*Command Record Definition*	*Return Record Definition for 'Command Accepted' Return Code*
I (CM) - CI Commands Enable/Disable	See 'Entry to CI Mode' under Command Code above.	<*LL*Itt*XXXX*> where: tt = zero filled timer value in seconds. Valid values: 00 – Inactivates timeout and disables CI commands 05-60 – Sets timeout in seconds and enables CI commands Notes: -Parameter is invalid if not one of the values/ranges outlined above. Receipt of any valid message resets the timer. (A valid record has a correct length field, correct CRC field, and is not less than the minumim record length allowed.) Timer will expire if a serial command is not received within the timeout time. Upon timeout, the processing covered in the section entitled 'Exiting CI mode – Terminated vs. Disabled'.	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.
M (CM) - Pump Model Number Request	None.	<*LLMXXXX*>	<*LLRAAAAAA*eeeeff*XXXX*> where: eeee = '3000' or '3100' ff = software version in hexadecimal. (For Example, 3F represents Rev 0.63)
Y (CM) - Pump Serial Number Request	None.	<*LLYXXXX*>	<*LLRAAAAAA*aaaaaaaaa*XXXX*> where: aaaaaaaaa is the 9 character pump id.
B (CI) - Silence Key Keypress	CI Commands Not Enabled, Power Off	<*LLBXXXX*>	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.

Command Code / Type and Name	*Modes when command is not supported*	*Command Record Definition*	*Return Record Definition for 'Command Accepted' Return Code*
C (CI) - Infused Volume Clear	Run Mode, CI Commands Not Enabled, Power Off	<*LLCXXXX*>	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.
E (CI) - Time and Date Setup	Run Mode, CI Commands Not Enabled, Power Off	<*LL*EYYMMDDhhmmss*XXXX*> where: YY = Year (00 - 99) MM = Month (1 - 12) DD = Day (Valid Day for Month/Year) hh = hour (0 - 23) mm = minute (0 - 59) ss = second (0 - 59) Note: the range of valid years is 1989-2088	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.
F (CI) - Pump On or Off	Run Mode, Door Open, CI Commands Not Enabled	<*LL*Fd*XXXX*> where: d = 0 turns pump off. d = 1 turns pump on d = any other character, then parameter is invalid.	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.
K (CI) - Keypad Lockout Setup	CI Commands Not Enabled, Power Off, Manual Keypad Lock Out	<*LL*Kmk*XXXX*> where: m=0 for Keypad unlocked. m=1 for Keypad fully locked. m=2 for Keypad locked with hold key unlocked. k = 0 CI mode termination does not unlock keypad. k = 1 CI mode termination unlocks keypad. Any other values for the 'm' and 'k' parameters not listed above will result in an 'invalid parameter' return code.	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.

Command Code/Type and Name	*Modes when command is not supported*	*Command Record Definition*	*Return Record Definition for 'Command Accepted' Return Code*
L (CI) - VTBI Set	Run Mode, CI Commands Not Enabled, Power Off	<*LL*Ldddd*XXXX*> or <*LL*Ldd.d*XXXX*> where: dddd or ddd.d = Requested Volume Limit in mL in decimal format. All 'd' characters must be valid decimal characters (0-9). Micro pumps have a valid range of 000.0 through 999.9. Macro pumps have a valid range of 0000 through 9999 with decimal limits accepted. (I.e. a volume limit of 999.9 is valid for a macro pump as well as a micro pump).	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.
N(CI) – Open Top Valve	CI Commands Not Enabled, Power Off, motor moving.	<*LL*NopnTv*XXXX*> where: A case sensitive Password, opnTv, is the only Parameter. Note: Any command following this should be delayed at least 11 seconds to insure proper completion.	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.
O (CI) - Run Mode Enter	CI Commands Not Enabled, Power Off	<*LLOXXXX*>	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.
P (CI) - Occlusion Pressure Set	Run Mode, CI Commands Not Enabled, Power Off	<*LL*Pd*XXXX*> where: d = 0 for 2 psi d = 1 for 5 psi d = 2 for 10 psi d = any other character, then paramter is invalid.	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.
R (CI) - Rate Value Set	Run Mode, CI Commands Not Enabled, Power Off	<*LL*Rddd*XXXX*> or <*LL*Rdd.d*XXXX*> where: ddd or dd.d is requested rate in mL/h in decimal format. All 'd' characters must be valid decimal characters (0-9). Micro pumps have a valid range of 00.1 through 99.9. Macro pumps have a valid range of 00.1 through 999 with decimal rates accepted. (I.e. a rate of 99.9 is valid for a macro pump as well as a micro pump).	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.

Command Code/Type and Name	*Modes when command is not supported*	*Command Record Definition*	*Return Record Definition for 'Command Accepted' Return Code*
S (CI) - Hold Mode Enter	CI Commands Not Enabled, Power Off	<*LLSXXXX*>	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.
T (CI) - Titrate	Hold Mode, CI Commands Not Enabled, Power Off	<*LL*Tddd*XXXX*> or <*LL*Tdd.d*XXXX*> where: ddd or dd.d is requested rate in mL/h in decimal format while running (not in KVO). All 'd' characters must be valid decimal characters (0-9). Micro pumps have a valid range of 00.1 through 99.9. Macro pumps have a valid range of 00.1 through 999 with decimal rates accepted. (I.e. a rate of 99.9 is valid for a macro pump as well as a micro pump).	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.
X (CI) - User LCD Text Setup	CI Commands Not Enabled, Power Off	<*LL*Xdaaaaa*XXXX*> where: d=0 will disables both user message lines. d=1 will replace line 1 message with aaaaa text. d=2 will replace line 2 message with aaaaa text. d = any other character, then parameter is invalid. aaaaa is variable length text (20h - 7Eh, excluding '<' and '>'). 0 - 11 characters for line 1 0-16 characters for line 2. Notes: This command allows the host to replace portions of the text on the default screens for primary and secondary modes. Any text specified will replace text for the specified line on the default screen. The last 11 characters of the first LCD line and the entire 16 characters of the second LCD line may be replaced. Text length of 0 will disable user text for the line specified.	<*LLRAAAAAA*aaaa.abbbb.bccc.c*XXXX*> where parameters are as described for 'D' command response.

Pump Powered Down - AC/Battery

The Rate and VTBI values are always retained over a power cycle, regardless of the power source.

The occlusion pressure setting will always be defaulted upon power down, regardless of the power source.

The following parameters/modes are retained when powered down on AC, but are cleared/disabled when powered down on battery:

- CI Commands/Serial watchdog timer
- User defined LCD text
- Remote keypad lockout.

The pump, when powered down and not attached to AC power, is incapable of command record processing. No response record will be returned to the host.

Exiting CI Mode - Terminated vs. Disabled

CI mode may be *enabled* or *disabled* by the host. It may also be *terminated* by the pump software, but only after it has been enabled by the host. CI mode termination ends host control until CI mode is re-enabled by the host.

CI Mode Termination

The following scenarios will cause CI mode to be terminated:

- Any front panel key press on an enabled key.
- A key press on the hardware front panel lockout switch.
- Serial watchdog timeout.
- Opening the door when pumping.
- Power off while on battery.

In the above cases the following processing will be followed:

- Disable watchdog timeout.
- Disable further CI commands.
- Clear any user defined LCD text.
- Unlock the remotely locked keypad if the option to do so was set (See Table 1 entry for keypad lockout).
- If pumping, go to KVO.

Note: Opening the door when powered up but not pumping or powered down on AC will not affect the current CI mode.

CI Mode Disabling

Exiting CI Mode by use of the 'I' command (set timeout to 00) will disable the watchdog timer and disable CI commands, but will not clear user defined LCD text nor unlock the remotely locked keypad.

Response Time-outs and Error Processing

It shall be the host's responsibility to monitor pump responses, detect a no response time-out and detect all other problems inherent in serial communication. Error detection and recovery are the responsibility of the host.

At 9600 baud, the typical command/response cycle time will be approximately 1/2 to 1 second. This time is measured from the time when the host starts to transmit a command until the time when the pump completes the transmission of the response. At 300 baud, the command/response cycle time may exceed 2 seconds. Three seconds is the minimum recommended response frame time-out value.

Any framing, overrun, or overflow conditions will be ignored and the problem will be sensed by means of the CRC check.

Problems that the pump encounters while executing commands will be handled as outlined in the section 'Return Record Format'.

Summary of Handshaking and Hardware Connection

Handshake Signals

The host asserts RTS (Request to Send) prior to sending a command. If ready, the pump shall respond by asserting CTS (Clear to Send) within 20 milliseconds of RTS active. The host may keep RTS asserted indefinitely. Unless there is a fault, the pump shall keep CTS asserted as long as RTS is asserted.

Hardware Connection

The Model 3000 uses a 9-pin sub D connector with female pins/male housing. The pin definitions are defined below:

Pin #	*Definition*
1	No Connection
2	Receive
3	Transmit
4	No Connection
5	Signal Ground
6	No Connection
7	Clear to Send (CTS)
8	Request to Send (RTS)
9	+5V out (35 mA max)

Note: This pin configuration does not allow a standard 9 to 9 pin connector, but requires reversing of pins 2 and 3 and pins 7 and 8 at one end of the connector.

Example Commands

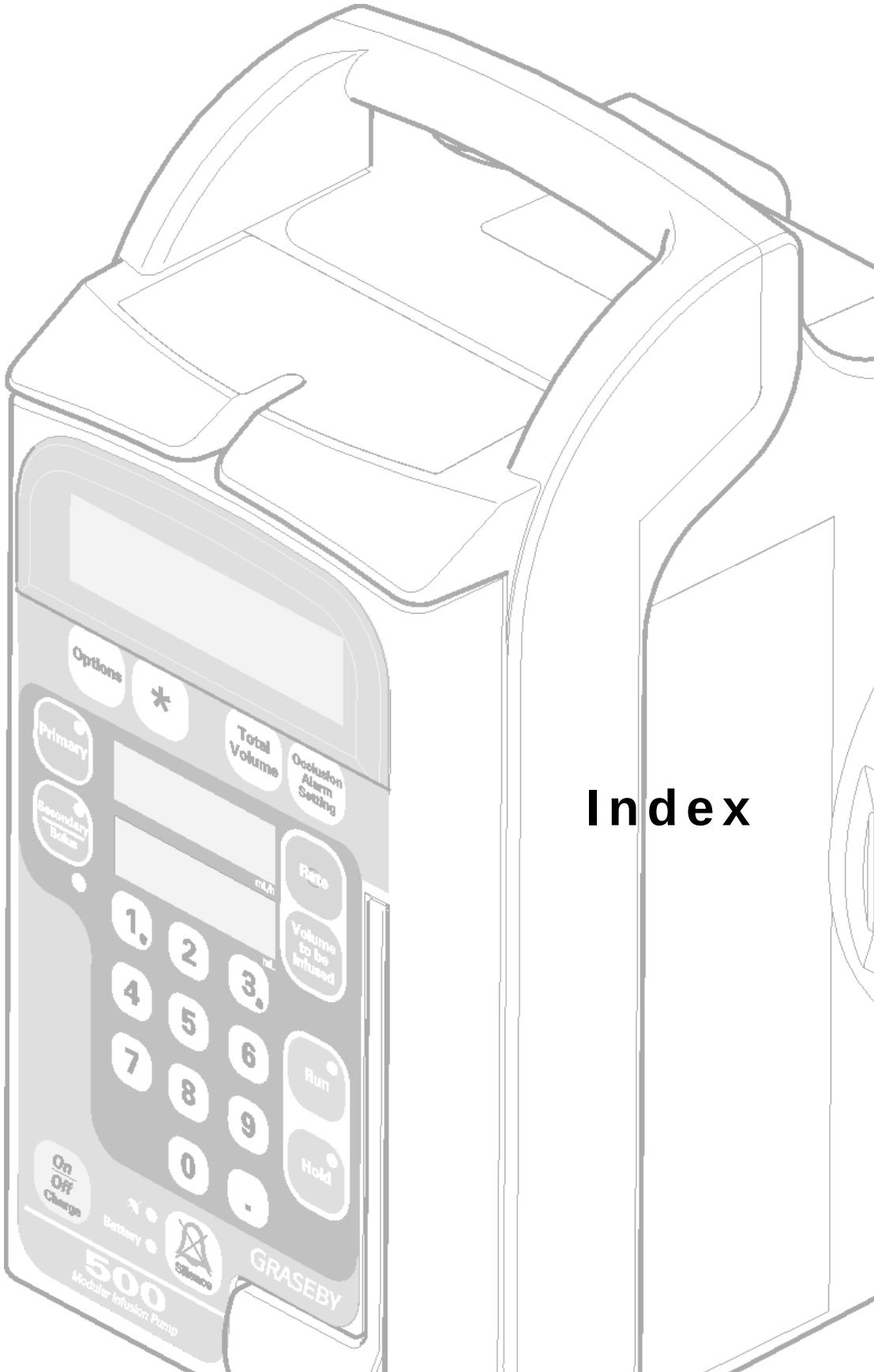
Version 0.68 and above

Command Description:	*Command Sent by Host:*	*Pump Response:*
Data query	<09Dxxxx>	<20*RAAAAAA*aaaa.abbbb.bccc.c*XXXX*>
Enable CI commands with 60 s timeout	<0BI60xxxx>	<20*RAAAAAA*aaaa.abbbb.bccc.c*XXXX*>
Set Limit to 1000 ml	<0DL1000xxxx>	<20*RAAAAAA*aaaa.a1000.0ccc.c*XXXX*>
Run	<09Oxxxx>	<20*RAAAAAA*aaaa.abbbb.bccc.c*XXXX*>
Set Rate to 100 ml/h	<0CR100xxxx>	<20*RAAAAAA*aaaa.abbbb.b100.0*XXXX*>
Hold	<09Sxxxx>	<20*RAAAAAA*aaaa.abbbb.bccc.c*XXXX*>

where:

R	= return code
XXXX	= CRC
AAAAAA	= alarm bytes
aaaa.a	= volume infused
bbbb.b	= volume limit
ccc.c	= rate in mL/hr

Index


Options
*
Primary
Total Volume
Occlusion Alarm Setting
Secondary Bolus
mL/h
Rate
Volume to be Infused
1.
2
3.
4
5
6
7
8
9
0
.
Run
Hold
On Off Charge
Battery
GRASEBY
500
Modular Infusion Pump

Index

Symbols

3000/3100
  jumper sensor 4 - 30
500/505
  jumper sensor 4 - 30
7 segment display unit 6 - 15

A

Accuracy
  pump 2 - 2
  test 7 - 14
Accuracy Tests 7 - 8
  checklist 7 - 16
Air detect system 2 - 1
  test alarm 7 - 14
Alarms
  audio backup 3 - 16
Analog sensor unit 6 - 15
Audio
  alarm test 4 - 26, 7 - 11
  circuit 6 - 7
Autolock Keypad parameter 4 - 6

B

Back of pump 3 - 3
Back pressure regulation 5 - 11
Backlight parameter 4 - 6
Backup audio alarm 3 - 16, 4 - 26
Bag
  empty state detection 5 - 10
  height above pump 2 - 1
Battery 3 - 13
  alarm check-low and dead 8 - 20
  charger circuitry 6 - 13
  depletion 4 - 6
  life 2 - 3
  removal instructions 8 - 1
  specification of 2 - 3
  use 4 - 25
Baud rate 4 - 25
Biomedical menu
  description 4 - 8
  parameters 4 - 10
  password 4 - 8
Bolus parameter 4 - 5
Boot up sequence 3 - 9

C

Calibrate
  components 8 - 14
  occlusion alarm 8 - 16
  pressure display 4 - 24
Cam housing switch 5 - 4
  adjustment 8 - 14
  disassembly 8 - 13
Cassette
  housing 5 - 2
  housing disassembly 8 - 12
  sensor (CS) 4 - 30
CE Marking 2 - 8
Checklist
  function and accuracy tests 7 - 16
Checks
  recommended yearly 7 - 7
Circuits 6 - 1
Cleaning
  agents 7 - 4
  precautions 7 - 5
  procedure 7 - 5
Clip
  safety 2 - 1
  sensor (CL) 4 - 30
Contacts
  empty bag 5 - 10
Continuous
  audio alarm 4 - 26
  backup alarm 3 - 16
Control/Interface commands 12 - 4
Coupler
  motor coupler realignment 8 - 11
CPU 6 - 3
  board initialisation 7 - 23
  board removal 8 - 5
CPU power supply
  spares/parts 9 - 11, 9 - 23

D

Date setting
  current date 4 - 29
  service due date 4 - 7
Decoding snapshots 4 - 12
Decontamination procedure 7 - 6
Diagram
  cassette housing and door 5 - 3
  front of pump 3 - 2, 3 - 3
  functional block diagram 10 - 2
  General assembly of the pump 9 - 3, 9 - 15
  modular connection system 5 - 13
  power routeing block diagram 10 - 3
  pumping mechanism 5 - 7
Diagrams
  waveforms 11 - 1
Dimensions of pump 2 - 1
Disassembly

pump 8 - 1
Disconnect
modular connected pumps 5 - 15
Display
board 6 - 14
board assembly removal 8 - 7
EL type 7 - 22
on pump 3 - 2
Display board
spares/parts 9 - 10, 9 - 22
Disposal of pump 2 - 8
Door
assembly removal 8 - 3
mechanism 5 - 2
sensor 4 - 30
Door Rear
reassembly 8 - 4
Dose-Rate Calculation
enable function 4 - 28
Dose-Rate Calculation parameter 4 - 6
DRC Recovery parameter 4 - 6
Drug list parameter 4 - 4

E

EL type display 7 - 22
Electrical safety standard 2 - 8
Electronic Circuits 6 - 1
Empty bag
contacts 5 - 10
sensor test 7 - 13
Encoder wheel 5 - 9
Epidural labels 1 - 2
Error codes 7 - 18
Events on pump 4 - 11

F

Feeler gauge spec 7 - 3
Fluid Ingress protection 2 - 8
Free flow protection 2 - 1
Front housing
removal 8 - 2
Front of pump 3 - 2
Front of the pump
symbols appearing on 2 - 7
Fuses 2 - 3
removal of 8 - 1

G

GMT Timestamp
on Time/Date display 4 - 22
parameter 4 - 6

H

hardware connection 12 - 7
Height
bag above pump 2 - 1
History
charging 4 - 23
clearing 4 - 30
displayed on pump 4 - 22

I

I/O
board 6 - 11
board assembly parts 9 - 12, 9 - 24
board assembly removal 8 - 6
signals 6 - 5
Indicators
hardware status sensors 4 - 30
'Mains operation' 3 - 2
'Primary infusion' 3 - 2
'Secondary/Bolus infusion' 3 - 2
Infusion
ranges of rates/times/volumes 2 - 4
rate and volume ranges 2 - 4
Initialising pump 7 - 23
Insistent alarm 3 - 15, 4 - 26
Interface
RS232 6 - 17
Interrupter detector 6 - 12
IPX1 2 - 8
IV pole 5 - 12

J

Jumper JP10 4 - 30

K

Keypad
autolock parameter 4 - 6
circuitry 6 - 14
diagram 3 - 2
lockout button test 7 - 10
test 7 - 9
KVO
alarm tests 7 - 14
default rate 2 - 6
rate entry parameter 4 - 5

L

Labels for pump 1 - 2
Language 4 - 25
LCD
circuitry 6 - 16
contrast test 7 - 8
depletion warning 4 - 6
replacing 7 - 21
Leakage current 2 - 3
LED
brightness test 7 - 8
Limits
max and min primary rate 4 - 4
maximum primary VTBI 4 - 4
maximum secondary/bolus VTBI 4 - 4

Linkage system 5 - 1
Lubrication 7 - 7

M

Maintenance
  procedures for 7 - 1
Max and min primary rate parameter 4 - 4
Max and min secondary/bolus rate 4 - 4
Maxi primary VTBI parameter 4 - 4
Mechanical Systems 5 - 1
Membrane switch replacement 8 - 8
Memory
  test 7 - 9
Menus 4 - 1
  Biomedical 4 - 8
  Service Functions 4 - 29
  summary of 4 - 1
  Technician 4 - 2
Message Display Light 4 - 6
Micrograms 4 - 28
  units parameter 4 - 7
Model number
  of pump 4 - 26
Modular connection system 5 - 12
Monitoring commands 12 - 4
Motor
  assembly removal 8 - 10
  control circuitry 6 - 11
  coupler realignment 8 - 11
  microprocessor for monitoring 6 - 6
  stepping 5 - 4
  torque test 7 - 13

N

Non volatile memory 6 - 6
Non-insistent alarm 3 - 16, 4 - 26
NVRAM
  corruption 4 - 20
  definition 6 - 1
  description of 6 - 6
  failure 7 - 23
  reinitialise after replacement 7 - 23

O

Occlusion
  monitoring 3 - 6
  sensing 2 - 6
Occlusion Alarm
  adjustment 8 - 15
  approx values of settings 2 - 6
  default setting parameter 4 - 5
On/Off key
  sensor (ON) 4 - 30
One step loading 5 - 2
Optional labels 1 - 2
Oscilloscope waveforms 11 - 1
Over pressure valve 5 - 11
  test 7 - 11
Overview of pump 3 - 5

P

Parameters
  Biomedical 4 - 22
  Service Functions 4 - 30
  Technician 4 - 4
Parts List 9 - 1, 9 - 13
Passwords
  biomedical 4 - 8
  service functions 4 - 29
  technician 4 - 2
PCB
  descriptions 6 - 1
  design 6 - 3
Pole clamp 5 - 12
Pole saver 5 - 12
Power 6 - 2
  circuitry 6 - 9
  cord 3 - 4
  down 3 - 12
  monitoring 3 - 13
  requirements 2 - 3
  supply 6 - 9
  supply board 6 - 3
  supply board removal 8 - 5
  supply voltage check 8 - 17
  suppy board removal 8 - 5
  up 3 - 9
Power-up tests 3 - 9, 7 - 8
Pressure
  calibrate the transducer 4 - 24
  display parameter 4 - 23
  plate 5 - 2
  plate position sensor circuitry 6 - 17
  plate position sensor test 7 - 11
  transducer 5 - 2
Programming keys 3 - 2
Pump
  assembly removal 8 - 9
  door 5 - 2
  history display 4 - 22
  identifier 4 - 4, 4 - 30
  indicators and displays 3 - 2
  spares/parts list 9 - 1, 9 - 13
Pumping
  cycle 5 - 6
  pressure calculation 4 - 19

Q

Quick Rate Change parameter 4 - 5

R

Rate
limits parameters 4 - 4
Rate taper
enable function 4 - 27
parameter 4 - 5
Rear housing assembly
spares/parts 9 - 7, 9 - 19
Rear of the pump 3 - 3
symbols appearing on 2 - 7
Reassembly
instructions 8 - 1
Recovery, DRC 4 - 6
RS232 board
spares/parts 9 - 11, 9 - 23
RS232 interface 6 - 17, 12 - 1
pin connections 12 - 7

S

Safety checks
electrical 7 - 7
Safety clip 2 - 1
mechanism disassembly 8 - 12
retention slot 5 - 2
switch 5 - 4
Secondary stop parameter 4 - 5
Self test 2 - 1, 7 - 8
Sensor
clip 6 - 12
description of all 5 - 10
door 6 - 12
empty bag 6 - 12
empty bag test 7 - 13
hardware status 4 - 30
jumper JP10 4 - 30
photo 5 - 11
pressure 5 - 10
pressure plate position 5 - 10
switch sensor interface 6 - 11
Serial number 4 - 30
Service codes 4 - 9
Service Date parameter 4 - 7
Service Functions menu
description 4 - 29
parameters 4 - 30
password 4 - 29
Service tool kit 7 - 3
Signals
I/O 6 - 5
Snapshot screens 4 - 10, 4 - 11
Software Command Parameters 12 - 5
Software commands
V0.67 and below 12 - 2
Software version 1 - 2
0.71 features 1 - 3
on Biomed menu 4 - 26
Solution
thick 2 - 1
Specifications 2 - 1
Standards 2 - 8
Stepping motor
operation 5 - 4
Storage of pump 2 - 1
Swing arm 5 - 11
Symbols on pump 2 - 7
System control unit (CPU1) 6 - 3
System faults 4 - 8

T

Technician menu 4 - 3
parameters 4 - 3
password 4 - 2
Test
accuracy 7 - 8, 7 - 14
air detect alarm 7 - 14
audio alarm 4 - 26, 7 - 11
conditions 2 - 2
door opening/loading 7 - 10
equipment for 7 - 2
functional 7 - 8
key function 4 - 30
keypad lock button 7 - 10
keypad/memory 7 - 9
KVO alarm 7 - 14
LCD contrast 7 - 8
LED brightness 7 - 8
motor torque 7 - 13
occlusion alarm 7 - 12
power up 3 - 9
pressure plate position sensor 7 - 11
self 7 - 8
valve integrity 7 - 11
yearly 7 - 7
Thick solutions, warning 2 - 1
Three-in-One 4 - 27
Time
to occlusion 2 - 6
Time and date setting 4 - 30
Timestamp
GMT 4 - 6
TPN 4 - 27
Transducer
pressure 5 - 2, 5 - 10
Trimpots R439 and R448 5 - 2
Troubleshooting 7 - 17
equipment 7 - 2
Trumpet curves 2 - 9

V

Valve integrity test 7 - 11
Version 0.53 initialisation 7 - 23
Version 0.63 initialisation 7 - 24
Version 0.65 / 0.67 / 0.71 initialisation 7 - 27
Version of software 1 - 2
Voltage 2 - 3
  checks 8 - 17
Volume Over Time
  enable function 4 - 28
Volume Over Time parameter 4 - 6
Volumetric
  standards 2 - 8
VTBI limits 4 - 4

W

Waveform Diagrams 11 - 1
Weight
  pump 2 - 1

The details given in this Manual are correct at the time of going to press. The company, however, reserves the right to improve the equipment shown.

For further information, please contact your local distributor or Graseby Medical direct on +44 (0)1923 246434

GRASEBY

Graseby Medical Ltd.
Colonial Way, Watford, Herts, UK, WD24 4LG
Telephone: +44 (0)1923 246434, Facsimile: +44 (0)1923 231595
http://www.graseby.co.uk

Part No. 0166-0250-A
April 2002
© 2002 Graseby Medical Ltd

smiths

Smiths Medical - A part of Smiths Group plc